EFFECT OF PROBLEM BASED LEARNING STRATEGY ON ACHIEVEMENT IN PHYSICS IN SUB-COUNTY GIRLS' SECONDARY SCHOOLS IN BUNGOMA COUNTY-KENYA

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A THESIS SUBMITTED TO THE SCHOOL OF EDUCATION IN PARTIAL FULFILMENT FOR THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN SCIENCE EDUCATION (PHYSICS EDUCATION) UNIVERSITY OF ELDORET, KENYA

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DECLARATION

Declaration by the candidate

This Thesis is my original work and has not been submitted for any academic award in any institution; and shall not be reproduced in part or full , or in any format without prior written permission from the author and/or University of Eldoret.

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DEDICATION

This Thesis is dedicated to my late parents, Dad Aineah Webola Machacha and Mum Keziah Makonjo Webola whose life experiences, and appreciation for the girl child education, encouraged them to sacrifice towards the provision of my training and gave me a foundation and a vision that has enabled my academic achievement.

ABSTRACT

The government of Kenya has invested enormously in educational resources, such as infrastructure development in schools, learning materials and professional development of teachers. Despite the efforts put in place to support access to quality education, enrolment and performance in physics in most sub-county girls' secondary schools in Bungoma County at Form 3 remain relatively low and poor. The study aimed at investigating the effect of Problem-Based Learning Strategy (PBLS) on achievement in physics using the topic fluid flow. Objectives of the study were to: investigate girls' ability to derive the equation of continuity, determine the gain in problem solving abilities of girls, establish the effect of PBLS on girls' motivation, and determine the ability of girls to illustrate Bernoulli's effects in nature using PBLS. The study adopted constructivist theories of learning. Quasi-Experimental design was used with eight schools targeted in Bungoma County. Stratified random sampling technique was used to select schools, then simple random sampling was applied to assign schools to experimental and control groups. The study sampled Form two students because the topic of fluid flow is taught at form two. The study used motivation questionnaire, Physics Achievement Test (PAT) and observation schedule. Two groups of each n=40 either control or experimental were exposed to pretest and post-test. The reliability coefficient was calculated using KR-Fomulla-20 and Cronbach's alpha at 0.75 and 0.70 respectively. Results show statistically significant difference in the ability of girls to derive the "equation of continuity", problem solving abilities, illustrate Bernoulli's effects in nature using PBLS and its effect on girls' motivation was relatively higher than conventional methods. The ability to derive continuity equation, problem solving abilities in fluid flow and the ability to illustrate Bernoulli's effects in nature led to improved girls' achievements in physics. Similarly, the motivation effect helped in enhancing enrolment of girls in physics at form three. The study recommends the method should be strongly advocated by policy makers, the government, curriculum developers, principals and teachers while teaching science subjects for effective skill development among the learners. The study is significant in bringing total reforms to CBC that call for the use of learner-centered instructional strategies to develop key competencies for skill development.

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LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ASEI/PDSI	Activity, Student, Experiment, Improvisation and Plan, Do, See and Improve.
CEMASTEA	Center for Mathematics, Science and Technology Education in Africa
CBC	Competence Based Curriculum
CT	Computed Tomography
DNA	Deoxyribonucleic Acid
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
FGM	Female Genital Mutilation
IEA	International Association for the Evaluation of Educational Achievement
ICT	Information and Communication Technology
INSET	In-Service Education and Training
KCSE	Kenya Certificate of Secondary Education
KNEC	Kenya National Examination Council
LASER	Light Amplification by Stimulated Emission of Radiation
MRI	Magnetic Resonance Imaging
NAEP	National Assessment of Educational Progress
PAT	Physics Achievement Test
PBLS	Problem Based Learning Strategy
SMASSE	Strengthening Mathematics and Science in Secondary Education
STEM	Science, Science Technology, Engineering and Mathematics
TVET	Technical and Vocational Education and Training
UNESCO	United Nations Educational, Scientific and Cultural Organization

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter covers the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, research hypotheses, and significance of the study, scope of the study, limitations of the study, assumptions of the study, theoretical framework, conceptual framework and definition of terms.

1.2 Background of the Study

Science has been viewed as a tool that assists growth in many countries. It plays a central role in spearheading industrial progress, innovation, promotes national wealth, better health and accelerates development. Physics as a science subject, is regarded as a basic subject (Ngatia, Changeiywo & Wambugu, 2019). All technology is beholden to Physics due to its emphasis on addressing phenomena involving the interaction of matter and energy. This interaction is necessary for the technological needs of the changing society (Ferri, Grifoni & Guzzo, 2020). Physics continues to influence applications in medicine (X-rays, CT-, Ultra-sound echo techniques, MRI techniques) and diagnostic patient screening scanning techniques (McCollough, et al.,2020) are based on physics principles. Currently, a wide variety of treatment techniques are made possible by the discovery of radioactivity and other high frequency radiations which exist. The unraveling of the DNA structure by X-ray diffraction to explain how chromosomes are replicated and the subsequent genome project required a significant input from physics techniques (Singh &

Kumar, 2022). Continuing research into challenges posed by diseases such as Cancer, Ebola, HIV/AIDS and Covid-19, will require physics principles in diagnostic and therapeutic purposes. The current fixation with information, communication technologies (ICTs) could not have occurred without the primal physics discovery of the transistor and integrated circuits. Computers, mobile phones and their attendant spin-off technologies show the indispensability of physics. Photonics and other quantum nanostructures show promise in terms of optical fiber-based communication systems (Singh & Kumar, 2022). Laser applications are used in commerce, communication and industry for Laser Range Finding, Information Processing, Bar Code Readers, Laser Spectroscopy and in Laser Surgery. Electromagnetism is vital in the generation of electricity, mobile phone communication, optical and satellite communication, portable electronics, radio and radar communication, and X-ray crystallography (McCollough, Kim, Wilcon, Logue, Greninger, Englund & Chu., 2020)

Despite the importance of physics application in areas as mentioned above, there is a problem in Physics education, in that, enrolment in Physics courses at all levels, among the girls is low in many countries including; Kenya, Nigeria, Uganda, Tanzania, and Rwanda (Njoka, 2020). The topic of unequal outcomes for men and women in science has been in the public domain for some time now, A wealth of research has documented differences in the academic achievement of boys and girls (Dweyer & Johnson, 1997). In science, the gender gap in interest, participation and performance is well known and has been the subject of intense scrutiny.

Worldwide, it has been observed that boys show significant greater achievement in science (Gamze, 2022). Observation of such differences have been reinforced by the view that boys are ‘naturally’ better equipped to excel in science (Hammond & Hammond, 2002). Such stereotypes that men are naturally more talented and interested in science are thought to influence the science, technology and engineering aspirations and achievement of boys and girls, men and women (Nosek, Banaji & Greenwald, 2002).

Data on low female achievement has come from the cross-cultural survey of science achievement carried out by International Association for the Evaluation of Education Achievement (IEA). The results of the three IEA science studies namely; First International Science Study (FISS), the Second International Science Study (SISS), and Third International Mathematics and Science Study (TIMSS) reveal that sex differences have been found in every subject area in the written science achievement tests. The sex difference favoured males. The 1999 and 2003 findings reveal that boys outperformed girls and had a larger variance. In addition, boys outnumbered girls in the top 25% in science performance (Chang, 2008).

The 1996 National Assessment of Educational Progress (NAEP) carried out in the United States earlier had reported that boys had outperformed girls in science achievement and the gender gap increased as students progressed in schools. A later assessment by NAEP in 2005 revealed that males outperformed females in science achievement in grades 4, 8 and 12. Females at all levels made relatively little gains in their average science scores since 1996. In most cases by grade 11, the areas of largest male advantage were physics, chemistry, Earth science and Space science (Kahle & Meece, 2004).

In many African Countries, the number of women enrolled in science-based training and those involved in science-based professions are among the lowest in the world (Frazier, 2008). Males continue to surpass females in the number of undergraduate degrees awarded in science and engineering fields especially in computer science, physical science and engineering (National Science Foundation, 2005). The share of females enrolled in science was below 20% in Botswana, Gambia, Guinea and Nigeria. The proportion in engineering was below 10% in Ghana and Swaziland (UNESCO, 2008).

Kakonge (2000) analyzed the Kenya Certificate of Secondary Education (KCSE) data for 1990-1996 after the inception of the 8-4-4 curriculum. The findings revealed that at both national and extra-county level, the averages of examination scores for boys were higher than those of girls. In physics, the national mean score was 45.8% for boys and 42.3 %for girls registering a gender percentage gap of 4.5%. The study carried out by Institute for Policy Analysis and Research (IPAR) on the performance of students in KCSE revealed that in science subjects the percentage gap in physics in the four Counties under study was 5% in Kiambu, 8% in Bungoma, 8.7% in Kisumu and no gap was established for Garissa where no single girl registered for physics (IPAR, 2003).

Girls are socialized into characteristics of dependence, nurturance and passivity. They therefore develop a set of attitudes and beliefs that do not promote high levels of achievement and participation in science. Studies have found that females have more negative attitude towards science. According to (Wasanga, 2006) the majority of girls found science subjects difficult and they perceived science subjects to be more useful to boys. Similary, Aghenta (2009) found that perceived difficulties of science occupations were significant factors preventing girls from entering Science, Technology, Engineering and Mathematics (STEM) fields.

Sex stereotyped careers is another limitation to enrolment. Children perceive various activities as masculine or feminine. Kelly (1995) explains how the masculine science image is constructed in schools. The masculinity of science is often the prime reason that girls have to tend to avoid subjects like physics at school, due to the disproportionally large numbers of males who study and teach it; the bias towards males in the curriculum material and male oriented classroom instruction.

In Bungoma County, low enrolment and low achievement at form three in physics in most sub-county girls' schools has been an issue of concern. Reasons to this observation vary from poor learner preparation, poor mathematical concepts amongst learners, inadequate teacher qualification as some may have challenges in pedagogical content knowledge (Njoka, Julius & Julius, 2021) and learner entry behavior to these categories of schools.

Many learners believe that Physics is difficult, abstract, and tedious, (Njoka, 2020) According to Amusa (2020) and Oluwadamilare (2021), many learners consider physics to be abstract, difficult and theoretical and therefore, they find the subject boring and non-enjoyable. Learners differ in what they perceive and do: for example, some in their prior knowledge and some in their study habit; some study to memorize the material, others to develop the understanding of it and while others to get good grades of it. Therefore, learning strategies should entail as to how learners learn what they learn or reorganize what they already know (Dejene, 2019).

Approaches to learning are associated with learning outcomes (Gamage, et.al., 2023). Since science education aims at preparing learners to think innovatively, investigate, evaluate, and experiment; then the study of science should be on teaching for conceptualizing rather than memorizing science content. Many countries are strengthening and investing in new methods and approaches to teaching and learning Mathematics and Science courses in order to produce more and better qualified candidates for higher level technical and scientific courses, such as computer systems analysts, big data Engineers, Architects, among many others. Traditional methods of teaching and learning are being revised for maximum outputs while learner- centered approaches have been embraced to sustain learner motivation and cultivate a feeling of ownership.

The teaching and learning of Physics have been affected by the low students' achievement as revealed by Kenya National Examinations Council (KNEC), K.C.S.E (2016-2022). Table 1 shows the overall candidature (enrollment) and performance scores obtained by students in physics in the K.C.S.E results between 2016 and 2022.

Table 1: Enrolment and Performance in Physics in Kenya National Examinations

Year	Paper	Candidature	Maximum Score	Mean Score	Std. Deviation
2016	1		80	32.49	19.3
	2		80	29.91	19.19
	3		40	17.15	6.5
	Overall	**149,790**	**200**	**79.53**	**42.40**
2017	1		80	24.57	15.82
	2		80	26.22	18.22
	3		40	19.33	8.33
	Overall	**160,182**	**200**	**70.09**	**39.59**
2018	1		80	22.98	14.87
	2		80	22.13	14.15
	3		40	19.43	8.5
	Overall	**172,679**	**200**	**68.54**	**35.31**
2019	1		80	25.63	13.83
	2		80	20.43	14.28
	3		40	19.13	7.98
	Overall	**184,559**	**200**	**65.18**	**36.09**
2020	1		80	24.57	15.82
	2		80	27.22	18.73
	3		40	18.78	8.13
	Overall	**189,460**	**200**	**70.59**	**42.68**
2021	1		80	26.22	18.22
	2		80	22.13	14.15
	3		40	18.04	8.31
	Overall	**192,550**	**200**	**67.39**	**40.68**
	1		80	25.63	13.83
2022	2		80	20.53	14.31
	3		40	19.03	7.88
	Overall	**204,433**	**200**	**65.19**	**36.02**

(Source*:* KNEC Report for KCSE 2023, 2022/2021Candidates)

From table 1, the overall enrolment in candidature in Physics has been increasing as from 2016, and was 204,433 in 2022 from 192,550 in 2021.This could be attributed to free primary, free secondary, (Basic education) and to the government policy of one hundred percent transition and completion. Nevertheless, this increase of 11,883 candidates

(6.68%) was low compared to the overall increase in candidature in 2022 K.C.S.E, which totaled 881,416 candidates, (Machogu, 2023). On performance, it can be noted that, there was a slight improvement in the performance of paper1 from a mean of 24.57 in the year 2020 to 26.22 in the year 2021, while paper 2 and paper 3 registered a drop in the performance. As noted, about the performance per paper, paper 3 which is physics practical has more or less maintained the same mean for the six consecutive years as from 2017.This being a practically oriented paper, perhaps the performance, which is expected to increase annually could be corrected by the use of problem-based learning strategy (PBLS).

PBLS can be referred to as a student-centered approach to learning that involves groups of students working together to solve a problem at hand (Hung, 2011), according to Sumita, Linda and Lesly (2022), PBL is a student-centered method of teaching where projects are kept at the helm in order to deepen the understanding of the content being taught. The level of thinking skills employed is very high (as opposed to lower-level thinking skills needed to digest fact-based information or concepts). The method is quite different from the traditional teaching method of a teacher presenting facts and concepts about a specific subject to a classroom of students. Through PBL, students not only strengthen their teamwork, communication, and research skills, but they also sharpen their critical thinking and problem-solving abilities essential for life-long learning.

An analysis of the students' responses for the KNEC Physics Examination of 2019 revealed that there was lack of knowledge on comparative words that show the differences in the physical characteristics or behavior of materials (KNEC, 2019) report.

Application of the knowledge in new task was challenging to most candidates. Therefore, teachers were advised to emphasize use of key words in given concepts, to logically analyze concepts and encourage critical thinking during teaching and learning process. This called for teachers to provide a strong working relationship among themselves and provide independent and collaborative learning environments and instructional strategies that are appropriate to the learner. In the conventional method of learning, learners are told what they need to know by their teacher, the learners then memorize the information given, and use the information to solve the problem at hand. This may be referred to as rote learning. Nevertheless, in PBLS a problem is assigned to the learners, then through collaboration and critical thinking, the learners identify what they need to know and apply what they have learnt to solve the problem. The teacher acts as a facilitator and the learning is student driven. PBL is a paradigm shift from traditional teaching and learning philosophy, which is more often lecture-based.

The SMASSE program which was piloted in 1998 and implemented in 2002 had made significant steps in advocating for the learner-centered approaches in the teaching of science and mathematics in secondary schools. During the baseline findings done in 1998, it was revealed that performance in physics among the science subjects in national level (KCSE) was extremely dismal. Before the SMASSE intervention was introduced, a baseline survey conducted to establish the cause of the persistent poor performance showed that the dominant classroom practices were ineffective (Solarte, 2021). Many teachers displayed poor mastery of content, lacked basic practical skills and innovativeness and poor teaching methods. This was manifested in theoretical teacher-centered approach to teaching with little or no lesson planning, a number of missed lessons, lateness and a number of unmarked exercises in students' books. Morale was generally low, there was generally complains of lack of teaching/learning materials. Activity, Student, Experiment and Improvisation (ASEI) and Plan, Do, See and Improve (PDSI) principle is based on the fact that students do not simply copy the science world; rather they construct their own meanings of it, through interaction of their observation, prior knowledge and mental processes. The PDSI approach advocated for planning the lesson based on the ASEI principles. Practice of ASEI lessons on effective content delivery has been increasingly entrenched in secondary schools in Kenya ensuring improved learner application that has promoted retention of content. In order to reach out to the large numbers of students in the classroom and to cater for the large individual differences in, especially, the teachers should embrace the use of approaches that are student and group centered. As noted, the SMASSE approaches sought to address the teaching approaches which were commonly in use during classroom instructional processes, similar to the present study which has looked at how modification on teachers' instructional processes could impact to a large extent on student motivation, attitude change and achievement in physics; hence the use of PBLS as a motivator towards improved achievement scores in physics (fluid flow).

Teachers' who had a teaching experience of five years from first posting and above, were subjected to the needs assessment survey by SMASSE through CEMASTEA training of 2017 and recommendations were made as from the year 2016,2017, 2018 and 2019. Reports from Monitoring and Evaluation of County In-Service and Training (INSETs), (CEMASTEA, 2019), identified teaching gaps which were to be addressed in order to effectively enhance performance and enrolment in Physics in Sub- County schools. Some of the gaps identified included: need for enhancement of knowledge, skills, values and attitudes during the teaching/learning of Science and Mathematics subjects, pedagogical issues during the lesson delivery, integration of ICT and inculcation of 21st Century skills (CEMASTEATPD, 2019). SIn Physics, the teachers agreed that some topics were difficult to teach and learn; such topics as, Fluid Flow, Waves, (reflection, refraction and interference), Electrostatics, (especially splitting of flame by charges since students don't see the charges). Refraction of light, (equations are too many especially where there is multiple medium), Current Electricity, (current flow in a circuit has too many equations). Some of the reasons that were advanced sighted that most of the concepts in physics were abstract, difficult and irrelevant. Students' misconceptions provided the pointers to the underlying problems and these were the issues this study sought to address in girls' sub-county schools in Bungoma County.

Form One selection and admission policy mandates the Ministry of Education to admit and transfer students in secondary education. This is to ensure smooth transition to secondary education level and to enhance access by analyzing Form One admission trends, identify challenges and make recommendations for way forward to the government. The policy has categorized learning institutions as National schools (109), Special Needs Education Schools (34), Extra County Schools (540), County Schools (1,049), and Sub-County Schools (5,823) (MOE, 2018). This facilitates selection of students according to students' performance in KCPE examinations. Kenyan learners who attain low marks in KCPE national examinations are admitted to sub-county schools, but this does not mean that they do not have the ability to excel in KCSE examinations. Parents are, nonetheless, not keen to have their children admitted to these schools since these schools do not post quality grades and some of them lack basic infrastructure. Majority of Sub- County schools are mixed though a number of them are single-sex secondary schools. Most of the schools are day schools, though a few are day/boarding schools. The schools admit students from majorly within the sub-county, from the immediate locality and they form majority of secondary schools in Kenya and are found in all counties.

In Bungoma County,176 out of a total of 385 schools are categorized as Sub-County schools. Out of these, there are 38 (Appendix F) of them purely girls sub-county schools while the remaining could either be pure boys' schools or mixed schools. This study looked at effect that PBL could have on the enrolment and performance of girls in sub-county schools in Bungoma County. The choice of this study was influenced by the fact that enrolment in these sub-county schools has persistently been low and the performance of the few girls who choose the subject at Form 4 remain comparatively poor. This study set out to try to mitigate these anomalies, and especially in schools where physics has been made an optional subject.

Babalola and Ojobola (2022) posts that interests in learning improve by gender when there is maximum collaboration among teachers and adequate opportunities for learners to interact in groups. Students (boys and girls) study physics in form one and two. They then choose the science subjects they will study in form three at the end of term three in form two. Many girls do not select physics at the end of form two. The national enrolment shows that physics has the least enrolment of all subjects. A number of studies have been done by researchers to try to give reasons for this anomaly.

PBLS as a teaching strategy provides students with real-life experiences which in turn create enthusiasm, with a deeper level of understanding of the content. The level of engagement includes student reflections, observation and classroom discussions. During the PBLS lessons, girls are more actively involved in their learning which enhances the motivation to learn and therefore resulting to enhanced enrolment in physics.

It should be noted that physics is directly related to mathematics, since many principles in physics are expressed mathematically, thus mathematics can influence performance in physics. Many learners have a negative attitude towards mathematics and this attitude can easily be extended to physics since it borrows much from mathematics. A negative attitude towards the subject makes students to underperform in the subject during examinations. This is because negative attitude makes learners to lose interest in the subject resulting to failure to do as required of them. Both Macharia (2019) and Sibanda (2023) noted that many students do not select physics when given an option. Closely related in the same vein on this is because of poor mathematics skills. It should be noted that physics involves a lot of calculations and if the students' mathematics skills are wanting, then their performance in physics would also be affected. On the same note, lack of critical thinking and the ability of some learners to visualize what is studied in physics concepts and the applicability in real life situations makes physics unpopular to students as compared to other science subjects. Another very important factor that makes physics not to be popular among learners is the way it is taught. Physics is a subject that requires valuable time and practice to be understood. Physics teachers should not therefore be in a hurry to cover the syllabus while students remain stuck without understanding. If physics concepts are not taught step by step, then the students find it tough to achieve the best. Physics involves a lot and therefore need learning and teaching strategies that simplify it making students to capture details in depth and master them, thus the need for learner centered approach in teaching like use of PBLS.

The performance of Physics in Bungoma Sub- County girls' schools is low unlike that of Biology and Chemistry as in (Table 2). Recent findings show that beliefs and attitudes about the ability and effort are related to gender differences in achievement particularly in sciences and mathematics (Chala, Kedir & Wami, 2020; Njoka, 2020).

Physics helps the learners to develop critical thinking because of its high dependency on mathematics concepts. The fact that mathematics is not a favorite subject for most low performing students could be a reason why they shy away from physics. The performance in physics like other subjects depends on the spatial ability of the learner (Twoli, 1998). Given that girls exhibit low spatial ability than boys and especially in schools of one gender (girls only), this may explain why there is a low enrolment and performance in physics among girls' schools.

The socialization of girls among African societies is different from that of the boys (Nalobile, 2014). Boys perform vigorous activities requiring activation of the mind; while girls are subjected to light jobs (housekeeping and cooking): thus this explains why girls are not likely to develop a more positive attitude towards sciences (physics) and mathematics. Table 2 shows enrolment in science subjects in some sampled out form three sub-county girls' schools in Bungoma County.

Table 2: Enrolment in Science Subjects in Form Three Sub-County girls Schools-Bungoma County (Expressed in Percentages)

School name in Bungoma County	Enrolment of Biology	Enrolment of Chemistry	Enrolment of Physics	Total as per Class
K	98.32	97.95	28.73	100
DB	100	100	12.04	100
N	100	100	11.11	100
L	100	100	15.38	100
LK	100	100	11.11	100
KB	100	100	1.67	100
FG	100	100	6.49	100
MO	100	100	15.75	100
TG	100	100	10.2	100
RS	100	100	8.94	100

Source*:* County Education Office (2019). Bungoma County Evaluation Cluster form three October /November 2019. (NB: K, DB, N etc. are girls' school names coded for anonymity purposes.)

As seen from Table 2, in all sampled schools, almost all girls at form three .opt to take both Biology and Chemistry, as indicated by the percentage enrolment in each subject. The least chosen science subject at Form 3 level was Physics (which was having the lowest percentage enrolment in all sampled schools). Reasons which may be advanced to this observation vary, but could include: shortage of trained Physics teachers, which cause many schools to resort to deploying untrained personnel who assist in offloading the over-burdened qualified teachers. By so doing, the quality of instruction gets compromised since untrained personnel lack pedagogical and content knowledge of the subject, and knowledge of the modern trends in the teaching of physics (Chala, Kedir & Wami, 2020; Njoka, 2020) Secondly, physics has a number of topics that lack teaching/learning resources/apparatus for instructional purpose in most upcoming sub-county schools, therefore learners are left to make meaning of what is taught, as this is done mostly theoretically (Njoka, 2020). Moreover, Physics is considered abstract, difficult, boring and therefore non-enjoyable to a majority of learners (Amusa, 2020).

There has been a general steady decline in academic achievement scores in sciences and mathematics of high school students and this has caused a deep concern in many African countries (Iwuanyanwu, 2022). The KNEC reports of the years 2013, 2014, 2015,2016,2017 and 2018 indicate that the performance of Physics at KCSE was ranked low as compared to other subjects (KNEC, 2013, 2014, 2015, 2016, 2017, 2018) reports.

Problem Based Learning Strategy (PBLS) is essential for technological development and the understanding of scientific concepts, scientific knowledge, and other social-economic needs. Such a strategy gives learners opportunity to explore what interests them and to design their own learning activities/projects, take leadership in learning activities, do much of the communication during learning through discussions and respond to a teacher or peer questions. It should be further noted that the ongoing curriculum reforms in Kenya with a shift to Competence Based Curriculum (CBC) call for the use of learner-centered instructional strategies. It is therefore important for teachers to use learner focused instructional strategies so as to develop competencies among learners to enable the learners to fit in the 21^{st} century society

Appropriate practical work enhances learners understanding, process skills and improves enjoyment; thus, doing practical work from the early part of secondary school enhances manipulative skills. The students are therefore expected to make correct observations, readings, recordings, evaluation and interpretation. These skills help the learner to concretize abstract ideas and concepts (Mang'eni, Ronno & Murei, 2018). This study therefore investigated how problem-based teaching strategy could be utilized in the teaching of the topic of Fluid Flow taught as the last topic at form 2 before learners choose subjects at form 3. The research categorically focused on the sub-county girls' schools in Bungoma County because of the low enrolment of girls in physics at form 3 in these schools and the poor performance depicted by those students who take the subject at this level. The research investigated the learning styles of the girls and further explored the effect of problem-based teaching strategy on the topic of Fluid Flow. This topic is perceived as being abstract due to the mathematical concepts involved. It is hoped that knowledge of the challenges facing the learners in the above category of schools in Physics will inform curriculum implementers on the need for a better methodology to create interest and motivation in the learners in average performing secondary schools in the western part of Kenya.

1.3 Statement of the Problem

Despite the efforts put in place by the Kenyan government in support of free, inclusive and Compulsory basic education in order to attract and retain students in school, (Basic Edu. Act, 2013), enrolment in Physics in most Sub-County girls' secondary schools in Bungoma County at Form 3 remain low (Table 2) and performance for the same few students at K.C.S.E is poor. This is evident from results of KCSE for the years2016 to 2022 as shown in Table 3

Table 3: Performance and Enrolment of Female students in Science Subjects in the years (2016-2022) in Bungoma County

Year	Total Candidature	Subject	Enrolment (Females)	Percentage Enrolment	Subject Mean Score
2016	23,120	BIOLOGY	10,798	46.70	4.163
		CHEMISTRY	10,798	46.70	3.961
		PHYSICS	1,555	6.73	2.930
2017	25,666	BIOLOGY	12,229	47.65	4.574
		CHEMISTRY	12,229	47.65	4.450
		PHYSICS	1, 635	6.37	3.311
2018	28,095	BIOLOGY	13,545	48.21	4.791
		CHEMISTRY	13,537	48.18	4.624
		PHYSICS	1, 735	6.18	3.101
2020	32,523	BIOLOGY	16,602	51.05	5.103
		CHEMISTRY	15,463	47.54	4.340
		PHYSICS	2, 511	7.72	3.361
2021	37977	BIOLOGY	16,340	43.03	4.700
		CHEMISTRY	16,211	42.69	4.533
		PHYSICS	3,533	9.30	3.285
2022	41904	BIOLOGY	18,223	43.48	4.860
		CHEMISTRY	18,107	43.21	3.875
		PHYSICS	4,036	9.63	3.355

(Source: County Education Office (2022) 2022 (KCSE) Results Analysis, County Education Office CEO)

This trend tends to put physics at a disadvantage. Physics is a fascinating subject but only appeals to few girls (as seen in table 3) as the rest of them may be afraid of being in poor performance records. Needless to say, Physics play a pivotal role in STEM courses which form the backbone of the TVET institutions now focused by the Kenyan government. It has been noted that the government is keen to expand this sub-sector and create jobs for more youth (Atieno, 2023), to meet the growing demand for skilled manpower. Therefore, this gap in enrolment and performance in Physics and other science subjects among girls in Bungoma County need to be narrowed for enhanced enrolment and performance in science and technical courses among females at tertiary level. The anomaly could perhaps be corrected by use of problem-based learning (PBLS) strategy, to target topics in physics that are mathematical and are deemed to be “abstract” to the learners. It is hoped that use of this teaching strategy would narrow the gender parity index that exist in physics and cause improved enrolment and performance among the identified categories of learners.

1.4 Purpose of the Study

The purpose of this study was to investigate the effect of PBLS on girls’ achievement in Physics using the topic ‘Fluid Flow.’ This topic is taught at Form 2 and it’s hoped that the investigation identified factors that would cause enhanced achievement in the subject at Form 3, in sub-county girls’ secondary schools in Bungoma County, Kenya.

1.5 Objectives of the Study

1.5.1 General Objective

To investigate if problem-based learning strategy (PBLS) can lead to improved achievement in physics in sub-county girls’ secondary schools in Bungoma County-Kenya.

1.5.2 Objectives of the Study

The specific objectives of the study were:

a) To determine girls' ability to derive the "equation of continuity" in physics (Fluid Flow) when using Problem Based Learning strategy

b) To determine problem- solving abilities of girls in physics (Fluid Flow) when using problem-based learning strategy.

c) To establish effect of problem-based learning strategy on girls' motivation towards "Fluid Flow" compared to conventional teaching methods.

d) To determine ability of girls to describe experiments to illustrate Bernoulli's effects in nature when using problem-based learning strategy.

1.6 Research Hypotheses

The research was guided by the following null hypotheses;

Ho1: There is no significant difference in achievement scores in ability to derive "equation of continuity" in the topic Fluid Flow between girls who are exposed to problem-based learning strategy and those who are taught using conventional methods.

Ho2: There is no significant difference in problem solving abilities towards learning Fluid Flow between girls who are exposed to Problem Based Learning Strategy (PBLS) and those taught using conventional methods.

Ho3: There is no significant difference in level of motivation in physics (Fluid Flow) among girls who are exposed to Problem Based Learning Strategy (PBLS) and those taught using conventional methods.

Ho4: There is no significant difference in achievement scores in ability to describe experiments illustrating Bernoulli's effects in nature, between girls exposed to Problem Based Learning and those who are taught using conventional methods.

1.7 Significance of the Study

The rapid advancement being witnessed in the 21st century society brings along with it a wide range of societal, economic, and personal challenges. To live and work successfully in this 21st century society, learners require unique skills that enable them to adequately face the challenges and adapt to new ones. To help learners acquire these skills, there is need for a paradigm shift from the traditional classroom of teacher-centered instruction to learner centered, where the learner takes the center-stage and the teacher becomes a facilitator of the learning process. Characteristics of teacher-centered classroom include; the teacher being the center of knowledge and in charge of the learning process while the learner is a passive receiver of knowledge, (Gocić & Jankovic, 2022). The teacher does not allow learners to express themselves and direct their own learning, thus, the classroom remains orderly and students are quiet.

A learner-centered classroom on the other hand, has some of the following characteristics: Learners play active role in their own learning through asking questions, complete tasks independently, learn from peers through collaboration, group work is encouraged and roles are clearly defined between them; this encourages learning and innovation, (Barbosa & Souza, 2021). Learners are free to talk and therefore the classroom may appear noisy or chaotic. The role of the teacher is to facilitate students learning and comprehension of the subject material by organizing the environment to maximize efficiency and monitor learner's progress.

According to Nuraini, Asri and Fajri (2023), the use of appropriate teaching method(s) by science teachers should play a key role in helping students develop their ideas and process skills such as experimenting, observing, investigating, hypothesizing, predicting, integrating ICT during teaching and learning, drawing conclusions and communicating. PBLS leads to acquisition of problem-solving skills, enhanced achievement and motivation in Physics. This can ensure that the number of students (girls) taking science courses at the universities and technical courses increases if teachers employed effective and efficient teaching methods which facilitate students learning through promotion of cognitive and effective characteristics of the learner. Additionally, the ongoing curriculum reforms in Kenya with a shift to Competence Based Curriculum (CBC) call for the use of learner-centered instructional strategies. It is therefore important for the teachers to use learner focused instructional strategies so as to develop requisite competencies among learners to enable them fit in the 21st century society.

Physics is a vital subject for school leavers when making career choices at the universities, middle level colleges and for use in their daily lives. Good results are ideal for one to fit in technological advancement (Payne, Au & Dowell, 2023). Problem-based learning abilities will enable learners to have the ability of transferability of the learning. This is whereby once a skill has been acquired, it is transferred to a new area of application (Babalola & Ojobola, 2022) and this is the essence of what Physics is.

The results of this study would be used for further research on inventive teaching strategies in Physics education. The findings would play an important role in formulation of policies and strategies aimed at reversing the negative trends in Physics education; particularly the issue of under enrolment of the girl- child in the subject and under achievement in most sub-county schools in Kenya. The positive effect of PBLS on girls' achievement in this study would help in sensitizing policy makers and curriculum developers to formulate relevant policies that advocate for teaching strategies which promote meaningful learning.

The Ministry of Education may be provided with primary data on factors responsible for low enrolment of girls in physics in Bungoma County at form 3 and the effect PBLS had in creating interest and motivation. The ministry may also come up with intervention and set aside funds to support the inculcation of PBLS in schools and enhance capacity building for teachers on the strategy. The findings would go a long way in reclaiming the position of physics among girls as a critical subject for realization of development goals.

1.8 Scope of the Study

The study was conducted between the months of July 2022 to October 2022.The study was confined to girls in sub-county schools in Bungoma County and also it confined itself to the topic 'Fluid Flow' done in form 2 and involving form 2 physics teachers and students. All sub- county girls' schools in the county formed the accessible sample for the study. A sample of 8 girls schools took part in the study, selected using stratified random sampling technique. Due to the limited time that was allocated in researching, this study might not have been exhaustive and could leave out some important variables that would be relevant to this research. The sample which was selected could have failed to be a true representative of the whole population of Bungoma County. Since most sub-county schools in the county are in the rural areas, accessibility could have been a challenge, thus affecting the outcome of the study. Financial constrains was a factor that might have adversely affected the depth of this study. However, with enough resources, the study could have been more comprehensive and the sample size increased to improve reliability. Form 2 students were chosen for the study because the topic ‘Fluid Flow’ is taught as last topic in this class, then students choose to either pursue Physics or opt out of it at form 3 (Wambugu & Changeywo, 2008). Thus, enhanced enrolment in physics was noted at the end of Form 2 when students made choices of subjects in Form 3. The study focused on sub- county girls’ secondary schools due to low enrolment in Physics and also girls’ who got admitted to these categories of schools had the same entry behavior, thus, this provided the basis for generalization of the results.

1.9 Limitations of the Study

This study encountered a number of limitations such as:

a) **Insufficient prior research studies done on the topic of study in Kenya.** The limitation was solved by the researcher widening the scope of literature review geographically.

b) **Possibility of some respondents giving false information deliberately.** For mitigation, the researcher used split-half correlation procedure to verify the authenticity of the respondents.

c) **The study was conducted within a specified time as per the resources of the researcher** and, therefore, only identified variables of the sampled schools were studied.

d) **The topic that was covered in this study was as perceived in the approved KICD new syllabus** and, therefore, generalization of the results was limited to this topic of Fluid Flow and not Physics as a subject.

1.10 Assumptions of the Study

The study had the following assumptions;

a) The policy of public secondary schools' categorization would remain in force during the entire period of the research for the findings to be relevant.

b) The study was not to be interrupted by administrative constrains such as students' unrests and non- attendance (or absenteeism) of some students from schools.

c) Academic achievement continued being an issue of great concern during the entire period of the research

d) The teachers who were involved in the study were duly trained and qualified to teach physics effectively and had a minimum teaching period of five years, therefore any difference in outcomes was a result of the treatment given.

e) Examination results in sub-county girls' schools at KCSE in physics continued showing huge disparities during the entire period of the study

f) That PBLS would have an input on girls learning of physics in Bungoma County.

1.11 Theoretical Framework

The theoretical frame work adopted for this study was social constructivism theory of learning developed by Soviet Psychologist Lev. Vygotsky (1896-1934). Social Constructivism is based on the idea that learning happens through social interaction and acknowledges that as learners interact with others, their knowledge changes. Constructivist's theory view learners as constructors of meaning from input by processing it through existing cognitive structures and then retaining it in long-term memory (Wanjala, 2023). In this sense, learning is viewed as an activity which involves constructing meaning through a social process while students interact with one another as well. This objective is achieved in a Physics lesson through either class experiments (Babalola & Ojobola, 2022) or through virtual experiments where students work collaboratively in groups of two or more. According to the constructivist school of thought, knowledge is not transmitted into the student, instead students build meaning from their interactions with one another (Otieno, 2019). Constructivists' theorist assent that individuals actively develop knowledge they possess. This development of knowledge is a lifelong process requiring significant mental engagement in the learner (Jurkova & Guo, 2021). Constructivists do center on the following; they support and act in varied viewpoints, they employ major source beside scheming, inductive and objective resources, give confidence to students in prior knowledge as they construct new meaning and they let students react towards lessons as well as altering the teaching approaches used, Individual students learn through a continuous process of modifying and interpreting their own experiences. In their point of view the instructor provides learners with experience that let them to calculate and control objects, they reconstruct meaning further from students' inquest and discussions.

Students should be given opportunities to alter concepts, prove laws, observe and draw conclusions (Angelle, Derrington & Oldham, 2021). Constructivists teaching take into account what students come in with initially at the beginning of instructions. This makes the learners to practice and rebuild new experiences as they go up the academic ladder. Researchers have investigated many teaching pedagogies from constructivist teaching/ learning arrangement (Khoury, 2022); (Jeon, Lee & Choe, 2022). In restructuring their learning, students' information is clarified and exchanged all the way during dialogue and learners can expand technical facts. Learners are set for a chance to experiment their facts and their experiences with cognitive disagreement. They connect and get solutions to their problems.

Researches made known that constructivist teaching strategies are of use not only in attainment but also help learners build their views about science and enlarge their thinking ability. Njoka (2020) portends that prior to the constructivist theory, teaching methods included scientific inquiry. Most learners viewed science as a way of accepting facts about the world and promotion of conceptual change.

The science syllabus in high school needs to be moderated in a sense that strategies are rich in variables and conditions which can be designed into numerous teaching methods which would improve structural knowledge by a process (de Oliveira, Silva, de Oliveira & Maciel, 2021). This will be an ordinary aspect of constructivist learning, which creates opportunity for student's learning and understanding. Although different teaching approaches are being employed, students continue to hold wrong conceptions; that is why the current study is designed aiming to enhance the outcome of PBLS on student's achievement, problem solving abilities and motivation. The general objectives of this method are applicable to any situation. They address the needs of the learner at all levels. These needs may be in the domain of manipulative skills, observation skills, recording skills, application skills and promotion of curiosity and interest, each of which can be approached from a scientific perspective whereby the learner has to interact with his/her fellow learner. Practical work, therefore, will enhance the aspect of science in the students.

It is important to remember that constructivism is a theory that describes learning, not a method of teaching. Although a teacher may make decisions, and may base actions on beliefs that are consistent with constructivism, as a theory, constructivism does not suggest how an individual should learn but offers an account of how learners construct knowledge.

Having an understanding of the constructivist underpinnings of PBLS method, this enables teachers to reflect on the goals of teaching, how the classroom is organized, and the pedagogical strategies and methods adopted to promote learning. By using constructivism, as a learning theory which acts as a referent to analyze teaching and learning, it is possible to closely examine teaching and learning situations for their learning potentials. Ultimately, it is the learning potential and the learning that takes place that is central to practice. An understanding of constructivism aids in recognizing this when adopting PBL strategies in a classroom situation. PBL being a student-centered pedagogy that is based on constructivist learning helps learners to collaborate and have self-directed learning. With PBLS, students create knowledge and comprehension of a subject through the experience of solving a problem at hand.

Constructivism promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchange of ideas. Students must learn how to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing in group projects. In this model of learning, students are urged to be actively involved in their own process of learning. The teacher functions more as a facilitator who coaches, mediates, prompts and helps students develop and asses their understanding, and thereby their learning.

1.12 Conceptual Framework

Constructivists state that the instructor needs to guide the learners in an attempt to provide an environment conducive for students to construct meaning at individual and group level (Nadelson & Heddy, 2018), Knowledge is actively built by the students in collaboration with his/her world (Piaget, 1950, Njoka et al., 2021). This brings about self-directed learning skills which facilitates the construction of new knowledge. To help learners acquire these skills, there is need for a paradigm shift from the traditional classroom of teacher-centered instruction to learner centered, where the learner takes the center-stage and the teacher becomes a facilitator of the learning process. A teacher-centered classroom is one where the teacher is the center of knowledge and is in charge of the learning process which merely leads to rote learning, since the learner remains a passive receiver of knowledge, (Gocić & Jankovic, 2022). This happens because the teacher does not allow learners to express themselves and direct their own learning, thus, the classroom remains orderly and quiet.

Conventional approach refers to the traditional way of teaching wherein most of the time lecture method is used. This method of teaching is textbook centered, teacher dominant, and exam-oriented. The emphasis here is mainly in remembering and reproducing facts, principles and theories of learning. This method of teaching is unable to provide students with a personalized learning experience. The students are forced to follow the same pattern and learning style regardless of differences in learner interests, thus the main reason why students oftentimes find this strategy of teaching/learning boring and uninteresting.

The use of problem-based learning strategy provides students with the opportunity to develop skills which are related to working in teams, managing projects and holding leadership roles. PBL enables students to work independently, to develop critical thinking skills and analysis, self-directed learning and to apply course content to rea-life problems (Nilson, 2010). This teaching strategy is linked to constructivist teaching because it involves activities that define the teacher as a facilitator and enables students to construct meaning that lead to scientific learning. Moreover, PBLS is a hands-on exploration that enhances the construction or investigation process, letting students to discover by themselves thus making the students come to make sense of their experience gradually optimizing their interaction with the world.

When you investigate, you gather information about a problem. Investigation involves using your senses and planning. The difference between experimenting and investigating is that, in the former the ideas that are to be tested and the equipment to be used are provided; while in the latter the student has to think of the apparatus as well as the procedure to be used Njoka et al., 2021). It is therefore significant that a study that involves students in investigating science is likely to lead to meaningful learning as well as scientific achievement compared to conventional methods of learning. Rather than teaching relevant material and subsequently having students apply the knowledge to solve problems like it is in a conventional method, in PBLS the problem is presented first. There are considerations for using PBL which involve the students doing some of the following: one, examining and defining the problem, two; students exploring what they already know about the underlying issues related to the problem, three; determining what they need to learn and where they can acquire the information and tools necessary to solve the problem, fourth; evaluating possible ways to solve the problem, and finally to solve the problem and report the findings. The link between the independent variables, intervening variables, and dependent variables is diagrammatically represented in Figure 1

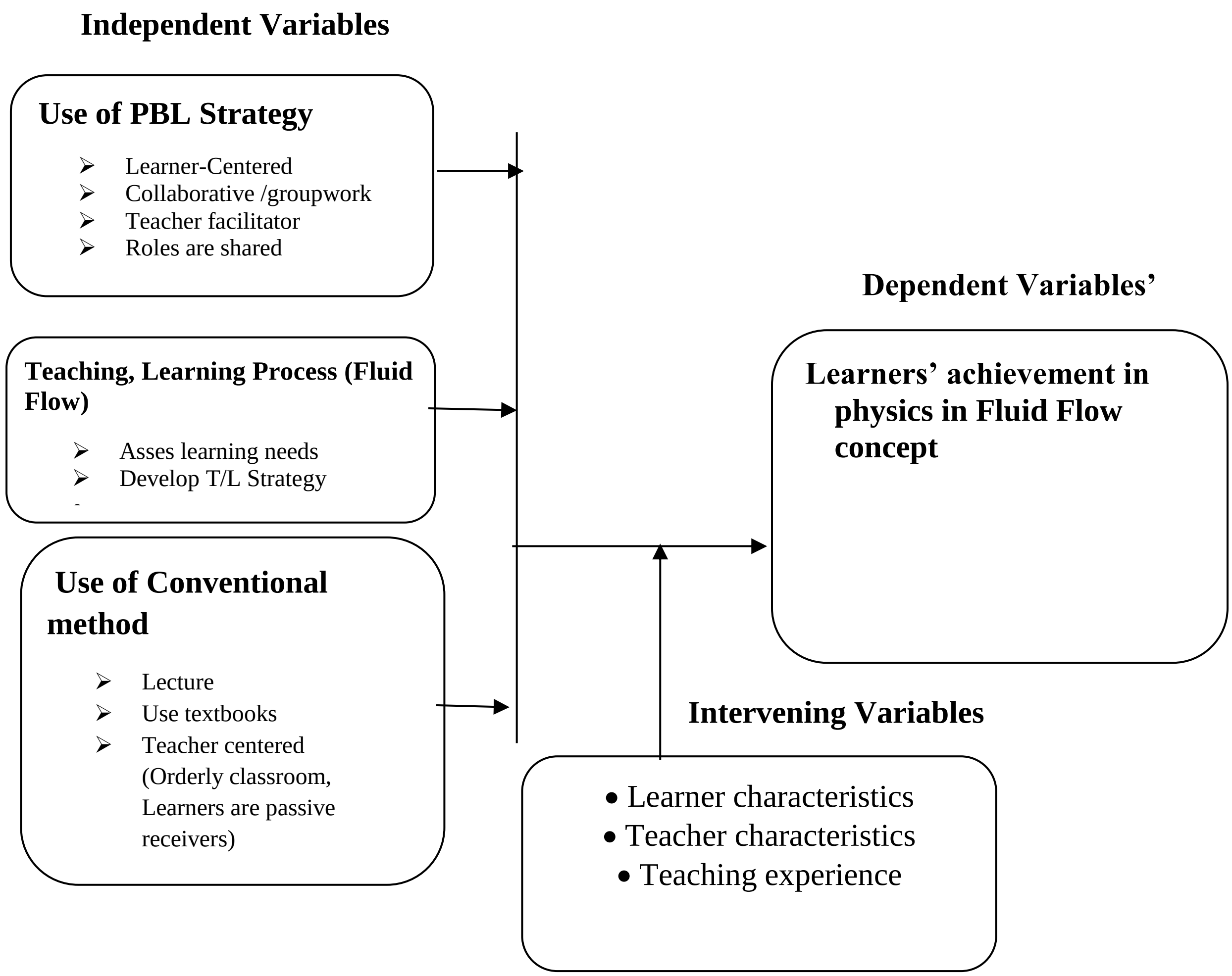

Figure 1: Conceptual Framework

(Source: Author. 2023)

Scientific Learning is subjective to factors such as, teacher-methodology, learner's prior knowledge, resources available, individual differences and classroom environment. The factors are interconnected to facilitate the teaching/ learning procedure, which eventually influences the students' achievement and motivation in Physics. Teacher training and experience determine how effective a teacher is. The study involved qualified Physics teachers with a minimum of five years teaching experience. It was assumed that these teachers taught in comparable ways (Gupta & Pathania, 2021).

1.13 Operational definition of Terms

Achievement - refers to students' performance in Physics Achievement Test (PAT)

Attitude- refers to students' perception or disposition towards physics

Classroom interaction- refers to the chains of events which occur, one after another, each occupying only a small segment of time during learning

Constructivism - theories developed in which learners are seen as constructing new meaning from input by processing it through existing cognitive structures and then retaining it in the long-term memory either individually or socially.

Conventional teaching strategy - in this study it refers to instructional strategy where the teacher dominates during learning process with minimal learners talk and activity. The instruction is teacher and text book cantered

Enrolment- This term was used in the study to refer to the number of students selecting physics up to the KCSE level.

Extra County Schools- Public schools within the county which are allowed to admit students from other counties (previously known as provincial schools)

Hands-on Activities- Activities that make the learner actively involved in physics practical through touch, feel, see, smell and taste and/or utilize his/her manipulative, recording, and observational skills to help understand important physics concepts

Investigative- sometimes you may have ideas why something happens or predict a Relationship between two variables, when you test your ideas, you are investigating.

Motivation- it is the effort which the learners put into learning as a result of their need or desire to learn. In this study motivation refers to students' effort put in as a consequence of their desire to learn Physics as a subject.

Performance - refers to the overall grades a student attains after a prolonged period of instruction.

Problem-based learning strategy (PBLS)- in this study refers to the effective student-centered approach of learning in which students learn about a concept by working in groups to solve the problem at hand. The problem is what drives the motivation and the learning. It is therefore an effective method to improve critical thinking and problem-solving skills in the learner

Problem-Solving - Application of scientific knowledge, concepts, principle strategies in an attempt to get a solution to a problem.

Science- is the system of thinking about the universe through data collected by observation and controlled experimentation. It is also a body of knowledge about the universe.

Science process skill - refers to all those activities that contribute to scientific learning.

The ASEI/PDSI science acronym- The *Activity Student Experiment Improvisation* and *Plan See Do and Improve* science concept has been widely adapted and adopted in **SMASSE**. It is a principle based on the fact that students do not simply copy the science world, but rather, they construct their own meaning of it as they are given an opportunity to construct scientific knowledge through the interaction of their observation, prior knowledge and mental processes. The PDSI of teaching advocates for teachers in the department collectively planning for a lesson and allowing one of them to execute it using the ASEI principles while they watch. They later critique the lesson and re-plan it for improved teaching.

1.14 Chapter Summary

In this chapter the researcher attempted to give the background of the study where the study observed that problem-based learning strategy has proved to be learner centered to equip the learner with 21st century skills. The research has shown that there is urgent need to solve perennial poor performance and low enrolment in physics subject especially among the girls in sub-county schools. The study identified pedagogical issues in teaching as the gaps to be addressed to build positive attitude towards physics.

The next chapter focused on the literature review of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter covers a review of literature related to the study. The study was based on what other scholars had researched on which is similar to what this research intended to look at. The literature was reviewed as follows; Literature on theoretical framework, General literature related to the study and literature related to the factors affecting use of problem-based learning strategy.

2.2 Literature on Theoretical framework

There are three theoretical views of teaching science which involve various approaches and methods. According to the early scientists and the proponents of deductive teaching, such as Christiaan Huygens (1629-1695), they believe that science is best taught deductively. They believe that a scientific investigation begins with a theory which provides initiatives and incentives for the investigation and that it controls inquiries. The learner is therefore supposed to investigate the principle or law and verify it. It is the prior theory or law that determines what observations, methods or experiments are relevant or irrelevant.Hagerik.et.al, (2010) argues that without theories, we do not know what to look for. In other words, there is a big difference between collecting data and doing science. A hypothesis, therefore, serves as a frame of reference guiding the scientist or researcher in their activities. A hypothesis can, therefore, be viewed as a reasonable guess or speculation that gives a solution or answers to the problem. Many science lessons enable students to learn science deductively. As can be seen from the above explanation, deductive teaching is a traditional approach in which, when a rule is given to the learners, they work to investigate and verify it

Nevertheless, many critics of deductive approach argue that the process merely clarifies, expounds or confirms the information that is already implied by the theories and thus it limits the research findings. Deductive approach of instruction is one where the learner proceeds from general to specific, abstract to concrete (Ngatia, 2019). Pure deductive work requires a formula for every type of problem, and extensive use of this method will demand for the blind memorization of a large number of formulae or concepts which would cause unnecessary heavy burden on the brain.

The inductive approach was first proposed by early philosophers and scientists such as John Hill and Galileo Galilei and was advocated by Francis Bacon (1551-1626) as the scientific method of teaching (Wolford, 2015). The inductive view sees science as critical and analytical activity in which concrete evidence precedes the scientific generalization (from specific to general). According to (Ngatia, 2019). the learner is helped to arrive at the general conclusion, to establish the laws and formulate generalization through the observation of particular facts and concrete examples.

This approach is logical, gives opportunity of active participation on the part of the learner; and is also based on actual observation of an event, experimentation and reduces dependence on memorization

The hypothetic deductive/inductive approach of teaching is that which integrates both the deductive and inductive forms. Use of problem-based strategy places responsibility for learning in the hands of the learner in line with the Activity, Student, Experiment, Improvisation (ASEI) and Plan, Do, See, Improve (PDSI) pedagogical paradigm.

This paradigm was advanced by Strengthening of Mathematics and Science Education (SMASSE), an intervention developed by corporation between the Kenyan government and Japan International Corporation Agency (JICA) in 1997.The purpose of the corporation focused on improving performance in mathematics and science education through promoting quality classroom practices which involved both hands-on and minds-on. Thus, problem-based learning strategy is both deductive and inductive in nature. This is because it consists of mainly formulating and testing ideas and concepts. It equally is inductive in nature, in that very often, we are not certain about the results we get. Nevertheless, even though we have confirmed our expectations, through experiments, our conclusions would still be tentative, doubtful and open to further investigation.

This study, however, focused on the third theoretical view, which encompassed the practical skill attainment in the girl-child during classroom interactional processes in Physics. The research incorporated the twenty first century teaching and learning skills. At this juncture, we may ask ourselves; what instructional skills do the 21st century teachers need to prepare students and how do these skills differ from the skills teachers needed in the past?

It should be noted that problem-based teaching and learning is one which aims at students learning to obtain knowledge by themselves and to work in ways that enable them to come up with new ideas which is a key tenet of modern society. This, therefore, means that teachers need to be trained to have the ability to facilitate learning effectively so as to enable learners develop a tradition for future self-learning. There is need to prepare learners to be culturally competent, talented, innovative, creative, problem-solvers, skilled and critical thinkers. Because many technologies give opportunity to critical thinking and problem- solving, students need to be provided with skills that will help them work collaboratively and with recent technology and be sensitive in a team. This will enable learners be good decision makers, be able to plan and use their time effectively, listen to one another and choose the right communication strategy at the right time.

Every teacher must therefore never lose track of the fact that perceptions are meaningful impressions obtained through the senses while concepts are the mental images abstracted from perception. For this reason, Physics teachers need to provide varied classroom experiences from which learners can develop perception which are raw materials for concept formation. This may be best summarized by a short poem from a student to a teacher;

I have five senses you must reach,

If I am to learn and you are to teach,

With touch, sight, taste and smell so clear,

Why must I receive all sense by ear?

(Anonymous,2012)

Advocates of the deductive-inductive approach view knowledge as arising from observation and that generalization and explanation can be relied upon because they are supported by and arise out of a body of observations, (George, 2021). Most mainstream philosophers of science have moved away from an inductive theoretical view of science to a more hypothetical-deductive one, which recognizes the clear distinction between data and explanations.

A model of scientific reasoning by Holman and Wilholt (2022) show that by observation and measurement, we can collect data on the real world. From the collected data, explanations of the real world could be conjectured so that it helps deduce some specific predictions to compare with data. When these are in agreement, they increase our confidence in matching the explanation to the real world. This is why PBLS teaching/ learning strategy would help to fill this knowledge gap in this study for effective learning outcomes in Physics when using hypothetical deductive approach of instructional for maximum achievement in average performing girl schools in Kenya.

2.3 General Literature Related to the Study

There has been a shift of emphasis of teaching science from the theoretical point of view to the exploratory, inductively, deductively and through experiments (hands and minds on). In this approach, proficiency in practical skills, and not masterly of structures is the primary aim. The more efficient way to learn lifelong skills in practical lessons is to place the learner as much as possible in the attitude of being a discoverer. The learner then brings in class the skill of imagination, curiosity and problem solving.

The teaching and learning of school science and Physics in particular can characteristically be described by placing it somewhere between two extremes of one or more continua. There is the *abstract- concrete* continuum, which imply the extent of the teacher profile during the learning process; whether a dominating one (controlling the amount, pace and direction of learning) or one that frees the learner to construct their own knowledge.

The other continuum is the *theoretical-practical* continuum. The theoretical end of this continuum are lectures, dictations, calculations, reading textbooks etc. In the practical region of this continuum, the teaching-learning process is carried out through activities such as demonstration, experimentation, discussion/group work, field work, observation, discussion and presentation, integration of ICT during the teaching and learning – all these lead to an investigative and/or open-ended learning.

Different scholars with an aim to improved performance and enrolment of students in science subjects have carried out researches in different fields on classroom interactional processes.

Research by Wafula, Momanyi and Omutange (2014) looked at factors influencing students' enrolment in physics in secondary schools in Bungoma East Sub-County, Kenya. The study intended to establish major factors that contributed to low enrolment in physics using descriptive survey design and purposively sampled Bungoma -East sub-county for the study. Stratified and simple random sampling were used to select the sample schools and participants respectively. Data was collected from 234 students selected from 12 secondary schools.

The study findings showed that students' attitude, gender, performance and timetabling were among the many factors which influenced learners' choice for physics. Teaching methods used and resources also impacted negatively on performance in physics. The study concluded that there was a very close relationship between enrolment in physics and students' attitude towards the subject and recommended that physics teachers assess the attitude of students so that appropriate measures are taken and that female students be taught by female teachers as role models.

While Wafula et. al identified factors such as gender, learner attitude, resources and teaching methods as those that could cause low enrolment in physics in Bungoma County and postulated possible mitigations to these challenges, the present study has further identified instructional methodology as a factor that has continued to jeopardize learner enrolment and achievement in physics in sub-county girls school in Bungoma county,

And, therefore, has done an in-depth study on the effect PBLS would have on girl-child motivation and achievement. The present study has adopted quasi-experiment design on 8 sampled sub-county girls' schools in the County and found that effective use of PBLS would enhance enrolment and achievement in physics among the learners in these schools. The study involved form 2 physics students using the topic fluid flow.

Muthwii (1987), carried out research on teacher-pupil discourse events and teaching styles of 14 Chemistry teachers in Machakos County in Kenya. It was found that teacher talk was dominant and pupil talk accounting only 16.7% of the total talk. Teacher's questions were of low cognitive level requiring recall of facts and principles. Muthwii focused on interaction process in Chemistry and centered on teacher-pupil talk.

Akweya, Twoli, and Waweru (2015), carried out research on the factors that influenced girls ‘performance in physics in five traditional “national” schools in Nairobi and Kiambu Counties, Kenya. It was found that the factors that specifically affected enrolment and performance were attitudes of students, their academic ability and teacher characteristics. The target population was form two class and teachers of mathematics and science in the five sample schools.

The study showed that learner’s attitude, learners’ ability and teacher characteristics affected girls’ enrolment and performance in physics in national girls’ schools. It was found that the girls had better positive attitudes and performance in learner abilities in physics in these schools than the boys. It should, however, be noted that Akweya et. al (2015) study was done in girls national schools’ category with students who joined form one with the best performance of over 400 marks (good entry behavior), and also these types of schools have enough learning facilities, as compared to the current study which involved sub-county schools and most of which are day schools in the rural set up (see Appendix VI).

The study used a survey design, unlike the present study which utilized quasi-experimental design in 8 sub-county schools, which were sampled from the nine sub counties of Bungoma county, using stratified random sampling technique. The results showed that teachers of physics in girls’ national schools were effective and efficient in instructional designs. The research, therefore, recommended use of constructivism approaches as methods of physics instruction among girls since the results showed that girls had a strong preference to physics practical work.

Njuguna (2002) did research on verbal classroom interaction patterns of selected secondary schools on Home Science teachers with their students in Nairobi County. It was found out that the lessons were highly controlled by the teacher, who determined the type of learning taking place. As a result, the students had no opportunity to participate in the lesson creatively. They had to comply with the teacher's directions and questions as they made verbal response. The study recommended teaching through creative inquiry patterns than drill-teaching.

Students must be able to express their own feelings and ideas. For them to do this, the teacher must provide an environment that encourages them to participate freely with limited directions. The study recommended that it is the teachers' obligation to help students develop a positive attitude towards that particular subject, and to succeed, the teacher should try to create situations which encourage students to discover and be creative. This would aid in development of 21st century skills among learners to help them fit in the present society, which the present study has attempted to address.

Both Kenni (2020) and Ekundayo (2022) investigated on Gender Dimension in Predictors of Students Performance in Practical and Theory Examinations in some secondary schools in Nigeria. It was found that male as well as female student performance in a test of theoretical knowledge in science-oriented subjects did not significantly predict their performance in theory examination. Male and female students' practical knowledge of science score could not significantly predict their mean practical scores.

It was recommended that principals of schools should ensure that both male and female students are actively involved in practical work weekly to enhance performance during practical work and effort should be made to bridge the gaps between theory and practical tests, Performance in science subjects, therefore was not to be gender discriminatory.

A number of challenges related to the effect of practical skills on learners' skills acquisition have been studied in Physics as a science subject at secondary school level.

Chepkwony, Ronno and Samikwo (2021) found that learners performed significantly in retention and application tests when taught using experimental approach as compared to the lecture method in secondary schools of West Pokot County in Kenya. Another area that has received attention is the content and presentation of handover information. Tamunoiyowuna and Omeodu (2022) observed that there was lack of and low utilization of the laboratory infrastructure for physics learning in Port-Harcourt of Nigeria. Thus, serious instructional challenges concerning practical work, teaching strategy and the level of school laboratory infrastructure identified in teaching and learning of physics could affect the enrollment and performance of girls in science-oriented courses. It has been shown, consequently, that attitude towards Physics selection has existed among girls, and perhaps will constantly continue.

Nalobile, (2014) investigated on Environmental Influence of girl-child access to secondary school education in Bungoma County- in Mt. Elgon Sub-County. The study revealed that enrolment of girls was low compared to boys. The study was guided by Gender Schema Theory and adopted survey research design sampling out 1611 respondents. Mixed methods were used for data analysis.

The study reported that girl-child access to secondary education was influenced by environmental factors (such as walking long distances to school in muddy terrain), cultural practices (such as female genital mutilation (FGM) and early marriages) and lack of parental responsibility.

The study recommended that the government supports local administration in eradication of FGM and early marriages and all forms of child labour. It should be noted that Mt. Elgon sub-county is one of the nine sub-counties that was involved in the present study and it’s likely that the same factors could affect the present study in some way, especially since most of the schools in this sub-county fall in the category of schools under the present study.

Achor, kurumeh and Orokpo (2012) did research on Gender Dimension in Predictors of Students Performance in Practical and Theory Chemistry Examinations in some secondary schools in Nigeria. It was found that male as well as female student performance in a test of theoretical knowledge in Chemistry did not significantly predict their performance in chemistry theory examination. Male and female student’s practical knowledge of Chemistry score could not significantly predict their mean practical scores.

It was recommended that principals of schools should ensure that both male and female students are actively involved in practical work weekly to enhance performance during practical work and effort should be made to bridge the gaps between theory and practical tests, Performance in Chemistry, therefore was not to be gender discriminatory.

Amadalo and Ochola (2012) carried out research on effect of practical work in physics on Girl's performance, attitude change and skills acquisition in the form-two form-three secondary schools transition in Kenya. They found that, the number of girls pursuing Physics as a subject at the form three level after form two was low. They attributed this to lack of motivation for engaging in activities related to Physics, practical work being identified as the influencing factor. The study involved two groups of girls from three sampled medium performing schools in western Kenya.

The experimental group was exposed to intensive practical work while the control group was conventionally taught the same content. They found out that the experimental group outperformed the control group in all research objectives.

Mbonyinyivuze, Yadar and Amadalo (2021) did research on Students' Attitude towards Physics in Nine Years Basic Education (9YBE) in Rwanda. They collected data from 380 students from Kayonza and Gasabo Districts in a Physics attitude test.

The research findings illustrated that more than a quarter of the participants felt that learning physics was boring and not fun. 39% thought that the subject does not relate to the real-world experience with a significant number having negative attitude to the subject. It was found also that the student's problem-solving skills were low. Responses from the rural schools differed from those of the urban schools. The students from rural schools needed to know more about the interpretation of 'new equations' to be able to apply to 'new physics problems', as they viewed physics as a set of facts and formulas to memorize. Thus, it showed that the school type as a factor played a role on attitude development of students towards physics as a subject.

The study strongly recommended use of interactive pedagogical approaches that could provide significant attitudinal gains of physics students, including Modeling instruction and Peer instruction. This would mean that teachers did not need costly laboratories, which would not be available in rural areas of developing countries.

It also recommended robust training for physics teachers on different interactive pedagogical strategies which were proven to provide a positive shift in students attitude and beliefs about physics which the present study has tried to address through use of learner-centered strategies such as PBLS. Therefore, we can be more vigilant to the girls in selection and teaching of Physics to avoid this gender stereotypes.

PBL as one of the interactive pedagogical strategies is a teaching/learning method that was introduced in Mcmaster University, Canada in 1969. Following up, this method has been widely used in varieties of disciplines such as management, engineering, agriculture and law. Howard Barrows was one of the academics who pioneered this method at an early stage. Barrows, Tamblyn & Barrows, (1980) stated that this method focuses on learning activities that are useful in solving problems of the daily life. The method focuses on the real issues and challenges helping learners to understand real life situations (Allen, Donham, & Bernhardt, 2011). The method also functions as a student-centered model lesson.

The concept of PBL method is the result of other learning theories such as Kolb's theory which emphasize on experience-based learning, Piaget Theory, Vgotsky, Lave and Wenger, which focuses on Constructivism and Social learning and also on Schon Theory which concentrates on the reflection processes (Sadlo, 2007).

The combination of these three theories forms a problem-based learning model. This method is also known as a form of learning that provides opportunities to learners to think and perform self-directed learning. Kirschner, Sweller & Clarrk, (2013) stated that this method is expected to help learners to resolve the issues or problems that are provided by using a variety of learning resources in the context of education, while the teacher play a role as a facilitator by providing guidance and relevant problems for the learners to solve. Teachers are also required to plan lessons properly and determine clear learning objectives to ensure that problems can be solved by the learners.

PBL has been widely adopted in diverse fields and educational contexts to promote critical thinking and problem-solving in authentic learning situations. With this growing practice and popularity of PBL in various educational and organizational settings, there has been an increasing number of studies examining its effectiveness on the quality of student learning and the extent to which its promise of developing self-directed learning habits, problem-solving skills and deep disciplinary knowledge achieves its intended result (Savery, & Duffy, 1995); (Yew & Schmidt, 2009); (Dolmans, Gijselaers, Moust, Grave, Wolfhsgen & Vleuten, 2002)

PBL is a pedagogical approach that enables students to learn while engaging actively with meaningful problems. Students are given the opportunities to problem-solve in a collaborative setting, create mental models for learning and form self-directed learning habits through practice and reflections (Schmidt & Moust, 2000). Hence, the underpinning philosophy of PBL is that learning can be considered a ‘constructive self-directed, collaborative and contextual’ activity (Dolmans, De Grave, Wolfhagen, &

Vleuten, 2005). PBL as a pedagogical strategy appeals to many educators because it offers an instructional framework that supports active and group learning-premised on the belief that effective learning takes place when students both construct ideas through social interactions and self-directed learning (Glaser, & Bassok, 1989).

Different studies have been done on the effectiveness of PBL as a teaching and learning strategy. Strobel and Van Bareveld (2009) analyzed a number of meta-analyses on the effectiveness of PBL and found that PBL is more effective than traditional approaches when the measurement of learning outcomes focused on long-term knowledge retention, performance or skill-based assessment and mixed knowledge and skills. PBL therefore appears to be a superior and effective strategy to ‘train competent and skilled practitioners and to promote long-term retention of knowledge and skills acquired during the learning experiences (Strobel, & Van Bavneveld, 2009).

Ng’etich, (2014), carried out research on factors influencing girls’ low enrolment and poor performance in physics. It was a study of secondary schools in Nandi South Sub-County, Kenya. The design of the study was descriptive survey carried out in seventeen secondary schools which were selected using stratified sampling and targeted form three physics students.

The study revealed that physics being an optional subject among the three, (Biology, Chemistry and physics) fewer girls opt for it as their subject of choice, which was in line with the present area of concern for this study where physics in sub-county girls’ schools register as low as one student or none at all among many students at form 3. The study concluded that the school environment played a major role in performance and enrolment of girls in physics, alongside the guidance and motivation which girls received both from their teachers and parents. The study recommended that parents and teachers be involved in guiding girls to help them change the negative attitude towards physics and the teachers to incorporate computational mathematics in the teaching of physics.

The study further recommended provision of more gender-responsive resources for learning physics. The above research, however, centered on factors that were to enhance girls' performance in physics; different from the present study which looked at the level of engagement that occurred among girls during exposure to PBLS.

Needless to say, the present research has been conducted to further examine the effects of PBL on girls' learning outcomes/achievement and enrolment in physics (fluid flow), in an attempt to minimize the gender parity which exist in science and technological courses and in workplace situations.

In a study carried out by Wamuta (2013), on factors influencing academic performance of girls of day- mixed secondary schools of Bumula Sub-County Bungoma County, a number of factors were identified by the research as to why girls in mixed sub-county schools performed poorly in national examinations. The study adopted descriptive survey design. The research found that family socio-economic factors, cultural factors and peer group influence were among the key factors that pulled down girl child performance. In addition, the researcher also identified factors such as teaching methods, learning environment and physical facilities in schools negatively impacting on girls' academic performance. On teaching methods, which has also been the basis for the present study.

Wamuta based his study on science subjects and found that lecture method dominated in all schools. Teachers essentially used lecture method, claiming that the time allocated for teaching particular topics in the syllabi could not practically work if varied methodologies were applied. Conversely, the present study adopted quasi-experimental design, and sought to examine how appropriate methodology used, could enhance girl-child motivation towards learning and as a result enhance enrollment at form three and appreciation for enhanced achievement especially in science subjects (physics) in the sub-county girl-schools, in Bungoma County.

Another recent empirical study done by Loyens, Jones, Mikkers and Van (2015) adds further evidence to the effectiveness of PBL. The authors randomly assigned groups of students to one of three conditions (PBL, Lecture-based, or Self-study groups) and found that students in the PBL group had a higher likelihood of conceptual change, outperforming those assigned to both of the other two conditions in conceptual tests immediately after the lesson, as well as in a delayed post-test.

Although this study was useful in supporting the efficacy of PBL, the authors acknowledged that more still needed to be done to better understand the processes involved within the PBL framework that enhanced learning.

A number of naturalistic descriptive studies have been done on the process of PBL. One such study attempted to focus on activities taking place in the PBL process (Yew & Schmidt, 2009). The authors examined in detail the verbal interactions of the entire process of a PBL cycle, including the self-directed period. The authors sought to investigated the extent to which PBL engenders certain learning dispositions towards constructive, self-directed and collaborative learning. They observed all three activities within the PBL cycle under study and found that 53.3% of episodes were collaborative, 27.2% self-directed and 15.7% constructive, Thus, they concluded that sequential influence of one PBL phase to the next was essential in impacting student learning outcomes.

In conclusion, the studies reviewed above in general show that learners perform significantly better and have good retention of what is learnt if appropriate strategies are effectively adopted. Problem-based learning strategy is an effective teaching and learning approach, particularly when it is evaluated for long-term knowledge, retention and application. The integration of theory and practical aspects in PBL strategy and the presence of a facilitator, promotes teamwork which enhances motivation and performance of the learner.

2.4 Factors Affecting Use of Problem Based Learning Strategy

Literature related to the factors affecting the use of problem-based learning were reviewed under the following sub-headings;

a) Academic achievement from integrating of PBLS in teaching of Physics

b) Determining the gain in problem solving abilities of girls in the topic Fluid Flow when using Problem Based Learning Strategy

c) Establishing the effect of problem-based learning strategy on girls’ motivation towards physics (Fluid Flow), compared to conventional teaching method.

d) Constructivist theory in learning of Physics

2.4.1 Academic Achievement from Integrating of PBLS in Teaching of Physics

Meaningful learning takes place as soon as students can bear in mind and make meaning of structural knowledge and if they apply what they have learnt or read, Gul, Kanwal & Khan, (2020); Njoka, et al., 2021; Chang, Wu and Chang, (2023). The capacity to relate information to a new state of affairs is determined by the extent to which students study physics all through insight. To structure knowledge in physics, lessons and teaching/learning activities need to be organized in such a way that girl-students are inquisitive, the context is meaningful and draws students' interest. According to Ogweno (2021), learning occurs when students look for information and relate it to pertinent existing new facts and principles in their cognitive formation. According to Njoka (2020), and Njoka et al, (2021) knowledge that a skill-rich setting is significant if education is lively (controlling, productive, introspective, intended and genuine (multifaceted and appropriate and helpful, concerted and chatty). Knowledge is significant, improved and liable to re-assign to new situations especially in real-life, Trott, Even and Frame, (2020; Meyer & Lima, (2023). Students, who have not acquired significant learning, learn by rote. Chala, Kedirand Wami (2020) assert that achievement in significant learning depends on three factors. These are, first, the context which measures the degree of cognitive strategy employment independently from knowledge acquisition, and secondly, the context which permits the students to construct concepts through their own cognitive efforts and employ this knowledge in proposing solutions and, making decisions.

The context is in-built on new knowledge, and if these factors are not met, then memorization takes over. Learner's skill-building for significant knowledge is a difficult process (Njoka, et al., 2021). Past knowledge is vital in knowledge-building process. Students construct their logical knowledge in physics ahead of what they previously recognize and accept as true. Students articulate new technical information by modifying and enlightening their present skills in physics and adding up innovative concepts to previous ones. Learners moreover, construct data based on their potential and environments Quílez, 2021; Suh, et.al., 2023). Learners, who do not, for instance, have hypothetical framework towards making-measurement, or tasks on how to evaluate, interpret, predict, observe and analyze what they do in practical work have a problem on how to construct data based on their potential and environment (Upahi & Oyelekan, 2020; Njoka, et al., 2021)

An important goal of education is the development of learners who can be responsible for, not only employing their existing knowledge but for creating new knowledge so as to do away with misconceptions that might hinder their capacity to find out new things (Suh, et.al., 2023). Student knowledge can be facilitated by others and can lead to the processing of information inside one's head before making generalization regarding the trend of data, making conclusions from observation or using experience and acquired knowledge (Suh, et.al., 2023).

Student-teacher relations are crucial for significant learning through problem-based teaching strategy. In addition, valuable learning needs students to be able to manipulate their own learning, in expression and self-evaluation (Costa, et. al., 2020). A major impediment to students' relation to various principles of human learning, which include the necessity of having a logical relationship between the objectives of instruction, content to be taught, the practice and application exercises is what is used to develop learning and evaluation methods used to asses mastery (Chu, et. al., 2021). Moreover, differences in assignments and assessment procedures will produce differences in students study patterns and differences in what students learn and retain.

Science education instruction involve conceptual change rather than infusion of information into a vacuum (Njoka, et al., 2021). Prior knowledge that students bring in a learning situation establishes a framework within which new input is interpreted. When the new knowledge brought to new learning situation is accurate, then the results of learning are authentic. Nevertheless, if prior knowledge would include misconceptions, the result may be distorted or be rejected of the new learning (Njoka, et al., 2021).

In order for students to construct new meaning in Physics learning, they should then include problem-based teaching and learning strategies to enable them adapt to inventiveness, problem solving, introspective thinking and creativity which are vital ingredients for logical and scientific growth for any country in this 21stcentury. Problem-based learning strategy when well utilized, helps students in construction of knowledge both in laboratories, social environments and classrooms. Gardner (1983, Cavas and Cavas (2020) and Yavich and Rotnitsky (2020) identified intelligences or learning styles that described ways of learning as:

a) Musical/rhythm, also known as auditory- they stated that these are individuals who prefer using sound and music and that in a classroom setup, this intelligence is promoted by learners listening to speeches or videos, reading out loud and participating in group discussion.

b) Verbal/linguistic- were individuals or learners who preferred using words, both in speech and writing.

c) Kinesthetic/Bodily/Physical- were those individual learners who preferred using body, hands and sense of touch. This intelligence may be promoted in class through taking field trips, visiting museums, playing learning games, doing hands-on activities, and writing notes.

d) Logical also known as Mathematical- are individual learners who prefer using logic, reasoning and systems.

e) Interpersonal or social- are individual learners who preferred to learn in groups or with other people.

f) Visual also known as spatial-are individual learners who prefer using pictures, images, and spatial understanding. In a classroom, visual intelligence is demonstrated through use of drawings, maps, outlining processes, watching videos, reading silently, graphs, tables.

With reference to the above learning styles, a teacher is, therefore, required to prepare learning activities which appeal to the diverse intelligences among the learners. Girls would undoubtedly learn more effectively if teachers match their methodologies to suit one or more of the intelligences. This calls for learner-centered approaches where teachers deliberately plan for varied activities to suit different learners.

Learner-centered pedagogy as seen earlier gives learners the opportunity to explore what interests them, enabling them to take leadership in learning activities, do much of communication during leaning and design their own learning activities/projects.

Varied challenges continue to confront the attainment of the projected educational goals as envisaged in the vision 2030 developmental strategic plan. Of the notable challenges is the poor performance in science examinations. Students are reported to possess poor mastery of the content, poor scientific language, poor understanding of concepts and inability to relate physics knowledge to real life situation (KNEC, 2019). Various modern approaches are being adapted to deal with the dilemma. In spite of the implementation of the diverse approaches to learners, achievement and enrollment in physics in sub-county schools among the girls is nevertheless poor. Problem-based teaching and learning strategy is a necessary component as one of the pedagogical models to facilitate meaningful physics learning. Optimizing on the effective use of problem-based learning as a strategy intends to assist girls comprehend the content of physics (fluid flow) in order to fill the gap.

Recent non-randomised studies concentrated on the effects of PBL instructional method on learners critical thinking. Liu and Pásztor (2022) conducted a meta-analysis study by cross-examining 50 empirical evidences ranging from 2000 to 2021. They sampled 5,210 respondents with 58 effect sizes. Their credibility of their research was tested by Egger's and Begg's p-values obtained at 0.231 and 0.060 respectively illustrating lack of publication bias as p-values were > 0.05. Results demonstrate that the use of PBLs has greater influence on learner's ability to gain critical thinking skills in science-oriented subjects. Similar studies attest to the influence of PBLS on acquisition of critical skills (Oliveira et. al., 2016; Ding, 2016; Ulger, 2018; Wang, 2018; Son, 2020; Liu et. al., 2020) which may not be an issue of implicit anticipation.

However, Lee et. al., (2016) found contradictions in other researchers' approach, arguing the ineffectiveness of PBLS on acquisition of learner critical skills. Most of the analyzed studies by Liu and Pásztor and other aforementioned researchers were social sciences and chemistry in higher institutions. The current study uses PBLS in secondary schools especially the girls undertaking physics as one of the STEM subjects and found that the strategy effectively improves the girls' test achievement scores with a magnitude of small to medium effect size.

2.4.2 The Gain in Problem solving Abilities of girls in Physics when Using PBLS

There is no creativity in rote knowledge; as this is merely lifting and duplicating what the instructor says (Njoka, 2020). Failure to use teaching strategies that are effective is a pointer to weaknesses in instructional methods used by teachers. When teaching physics concepts, teachers must consider the fact that students are not empty vessels into which information is poured; but rather that the students are dynamic participants in the learning process. It should also be understood that learners come from varied backgrounds and that they do not learn in the same way.

Hence, teaching should not be considered a linear process, with one-way delivery of content and concepts (Njoka, et al., 2021). Novel inventive instructional approaches such as PBLS are to be employed to improve achievement in problem solving skills, critical thinking skills and enhance motivation among physics students. A good teaching strategy promotes development of both cognitive as well as effective characteristics of the learner. The present study was designed to determine the effect of problem-based learning strategy on secondary school girls’ achievement, problem solving, and motivation towards Physics learning.

On average, students continue to perform poorly in science subjects as compared to social science subjects. A close analysis of questions performed poorly by the candidates in Physics in the years 2013-2019, (KNEC 2013, 2014, 2015, 2016, 2017, 2018 and 2019) show that students had glaring weaknesses in answering questions in all the three papers that were to be undertaken. Weaknesses noted generally include; poor interpretation of questions and poor interpretation of practical paper results obtained in the correct significant figures, poor scientific language, poor understanding of Physics concepts and application in the new tasks, and inability to relate Physics knowledge to real life situations (KNEC, 2013, 2014, 2015, 2016, 2017, 2018, and 2019). These weaknesses were most likely to be derived from poor teaching/learning strategies employed. Knowledge is taken to be an active constructive, cumulative, self-regulated and goal-oriented process in which the learner plays a critical role (Njoka, 2020).

Teaching should involve advancement of instructional methods that hold girl-child interest, and enthusiastic in the course of knowledge acquisition. Use of problem-based learning strategy proposed in this study is one way towards this end. Instruction has frequently focused more on transmission of information than on knowledge construction (Njoka, 2020). Students frequently would like to know the right answer Bennett, (2003), (Blumenthal & Blumenthal, 2020). It is therefore important to have student-centered learning environments, that give confidence, motivate learners to build up and set up a broad array of practical and meta-cognitive facts as well as broader variety of cognitive processes at school (Vu, et.al., 2022).

Schools will have to engage girls with strategies that will enable every girl-child to harness their potential through activities inclined towards equipping them with investigative skills that can help in life. Previous studies indicate that teaching/learning process in science and mathematics have centered on the cognitive aspects of the learners in terms of achievements, instructional methods used by teachers, motivation towards science and mathematics as well as factors that affect science performance (Hwang & Tu, 2021); (Assem, et. al., 2023). None of these studies sought to determine the effect of a variety of teaching strategies used with an aim of promoting constructivism among girls on new knowledge learning.

Constructivism theory says that learners construct knowledge rather than just passively taking in information. Learners communicate with each other and share their understandings, feelings, knowledge, and experience to come up with new knowledge. The teacher becomes the facilitator, and the learners are encouraged to interact, exchange views and experience and construct meaning and knowledge based on their needs.

According to Njoka (2020) and Sibanda (2023), Physics is difficult, uninteresting and has remained so for many decades. Such perceptions appear universal. Somehow the traditional system of Physics education has not been able to overcome this problem. Njoka (2020) notes that if we endow ‘our’ students with skills such as investigation, data presentation and evaluation of experimental results, significant thoughts and ingenuity, they will be better prepared for the future. Physics endeavors to appreciate the daily occurrences of phenomena such as eclipses, rainbow, lightning, mirages and laws governing their formation. By conception of these laws, we can better interact with and harness our environment.

Schools will have to engage girls with strategies that will enable every girl-child to harness their potential through activities inclined towards equipping them with investigative skills that can help in life (Young, 2000). Researches done in Kenya related to teaching/learning process in science and mathematics have centered on the cognitive aspects of the learners in terms of achievements, instructional methods used by teachers, motivation towards science and mathematics as well as factors that affect science performance (Kiboss, 2003 , Okere, 2004; and Changeiywo, 2000). None of these studies sought to determine the effect of a variety of teaching strategies used with an aim of promoting constructivism among girls on new knowledge learning.

Njoka (2020) portends, there are certain skills involved in a class investigation that students must have; first, reformulating general statement that are testable, second; criticizing given experimental procedures and suggesting improvement that could be made to them, and third; devising and describing the sequences of investigation (Suh, et. al., 2023). It should be noted that the first and second skills fall into the sensitivity of creativity- critical thinking skill (Sibanda, 2023) and the third, fall under problem solving skills. Moreover, in the course of scientific investigations, girls’ knowledge and understanding of concepts in Physics are made clear as explanations are made during group discussion and presentations of data. Okori and Ebere (2019) points that, most of practical work in Physics involves measurement and observation (data collection). The poor performance in Physics is due to factors such as teachers not using student-centered approaches, lack of experiments, insufficient trained teachers, and lack of resources (Chu, et. al., 2021).

Many teachers point out that low achievement in Physics is as a result of negative attitudes by the learners as well as omitted linkage between primary and secondary science syllabus (Njoka, 2020). Whereas school environments that are focused to high ability and competing for grades can increase the academic performance of some learners; especially the learners who are above average in performance, research suggests that many young people experience diminished motivation under these conditions. Girls, especially from average performing schools exhibit the highest de-motivation, when they are exposed to this kind of competition.

Girls, therefore, can be helped to understand Physics concepts, principles and laws in order to equip them with necessary skills for job opportunities in future through implicit teaching using problem-based learning strategy which helps the learner to be equipped and thereby augmenting their content and acquisition in the process (Sibanda, 2023). According to Hasanah and Shimizu (2020), there are fifteen process skills namely: discussing, planning, recording, presenting, applying, classifying, evaluating, experimenting, hypothesizing, interpreting, investigating, observing, predicting, inferring and questioning.

The science process skills above are based on the notion of transferability of learning. This means that once the skill is learnt/acquired, it may be transferred to new areas of application. problem-based learning strategy of teaching enhances the idea of 'science-for-all'. In particular it is believed that students do not forget the skills which they acquire easily, they will use these skills later in life even when they do not proceed to learn science to higher levels of education (Çakiroğlu, Güven & Saylan, 2020).

Thirdly, arguing in favor of the problem-based pedagogy is the fact that, it enhances student attitude and motivation towards learning of Physics. Many girls shy away from Physics because of the content approach which they believe makes the learning more abstract and difficult.

Fourthly, problem-based learning is more flexible, makes the knowledge more relevant to the students and it is hence motivating. It is on these reasons that the present study is designed. Both Njoka (2020) and Bett (2022) noted that nearly all the teaching strategies practiced in Kenya schools are mostly expository and facts oriented, making students to be passive. Wafula (2017 argues that the curriculum and the syllabus remain boring if not converted into exciting and interesting episodes by the teacher using the right teaching methods. As a result, there's need to improve the teaching of Physics subject.

Research findings in Kenya indicate that gender difference in physics achievement begin to appear in lower classes in secondary schools and increase in higher levels, to college and universities (Kisigot, Ogula & Munyua, 2021). This gender differences are attributed to the interaction of factors within the school environment. Ngonyani (2020) argues that science and mathematics in classroom has been depicted as ‘masculine’ subject and lacking link between the classroom and its relevance to the external environment.

Among the seven core competencies of CBC curriculum is critical thinking and problem solving. It is envisioned that learners with such competencies are critical for a nation’s social economic progress because education would have prepared them to fit into the contemporary society. In order for these learners to achieve the above skills, teachers need to adapt pedagogies that enhance students’ ability to ‘learn to think and think to learn’. Girls who are critically thoughtful and positively embrace problem solving throughout their learning, develop deeper engagement and understanding.

Teachers can create conditions that encourage students to actively engage in learning through critical inquiry, thus learners develop a repertoire of thinking tools that they learn to use independently. This leads to learners who have stronger competence with scientific inquiry skills. These scientific skills or scientific inquiry skills are also known as science process skills which include initiating and planning, performing and recording, analyzing and interpreting and communicating. A paradigm shift from teacher-centered or directed instructional emphasis to where students are more actively involved in the learning experiences leads to better achievement.

Njoka (2020) provides the intellectual groundwork in scientific benchmark inquiries and deductive or Piagetian concrete operational reasoning. Science process skills are attributed to hypothetical-deductive way of thinking Njoka (2020). The process skills will activate and build up girls’ intelligence of reliability inside personal erudition, increasing the permanence of their knowledge experiences, in addition to educating them about research methods above and beyond thinking skills that are used to get information. These are suitable for all discipline fields, as they indicate on the right view of scientific reasoning, when solving problems and planning experiments. It is of outmost importance for girls to know how to relate science process skills to reality learning, concepts generalization, theories and principles in Physics curriculum.

Problem-based learning strategy can be implied in the cognitive as well as psychomotor domain that can be engaged in problem solving. It is used in problem-identification, objective inquiry, data gathering, interpretation and communication. This method of teaching will foster desire for investigation and scheming skill in girls and deter rote learning. It will encourage the girls to be actively involved in learning process; a condition which makes it superior to others (Nicol, Gakuba & Habinshuti, 2022). Furthermore, its use increases the intransience knowledge and development along with solving problems, thinking critically and making decisions.

Some of the teaching methods that can be employed to promote problem solving are use of key inquiry questions, critical questioning, integrating ICT in teaching and teaching through problem solving. It should however be noted that problem solving is the process of finding solutions to difficult or complex issues. It is on this aspect that the study intends to use problem-based learning in teaching and learning of physics concepts at form two level at the sub-county girls' average performing schools to enhance enrolment and achievement in Physics.

Sholahuddin, et. al., (2020) carried an investigation on the effectiveness of 'cognitive style-based learning strategy' (CSBLS) in improving process- based skills among the elementary learners in Indonesia. They sampled two schools, one which was best school (above average performance) and the other one was good (average performance) school. The researchers used the CSBLS method for a period of five weeks in physics lessons to elementary learners of grade six in the range of 10 to 11 years old. One school was randomized with 33 learners while the other one with 39 learners and both schools included boys and girls. Two topics of ‘changes of substances’ and ‘conductors-insulators’ were covered in 10 lessons and the learners were assessed using a pre-test-post-test method. The findings showed that the method administered significantly improved learners’ science -based process skills. However, learners’ ability to demonstrate experiments and identify the guiding variables and principles or laws was somehow poor. They concluded that CSBLS catered for learners’ differences with unique levels of cognitive styles and development to improve critical thinking skills of the learners.

A further randomized study (Saputro, et. al., 2020) was carried out in Indonesia. The researchers surveyed pre-service trainers in a private university. They tested the self-efficacy on critical thinking using PBLS. They used quasi-experimental design with control and experimental groups each n=22 individuals. The control group was taught using lecture method while the experimental group was exposed to PBLS. One instructor with experience of 6 years was used to administer the process. Data was analyzed using inferential statistics with the aid of SPSS 17.0. The findings showed that PBL was statistically effective in improving the self-efficacy on critical thinking of the participants than the conventional method of teaching. These results were in complete agreement with the results of the present study which found significant difference in achievement scores in problem solving abilities towards learning of fluid flow between girls who are exposed to PBLS and those taught using conventional methods.

In the same vein, Irwanto, et.al., (2019) argued that the use of science-based process skills develops learners in finding scientific information, ability to develop critical skills such as solving problems and making decisions which improve their creativity and perception towards STEM subjects. Hence, Limatahu, Suyatno, Wasis and Prahani (2018) add that such skills should be considered at early years and developed continuously in the learner's lifetime. This argument could be true and valid considering that the Government of Kenya is modestly phasing out the 8-4-4 curriculum and implementing the Competency Based Curriculum. The current study investigated the use of PBLS through similar approach to CSBLS in the topic of 'Fluid Flow' among four girls schools each randomized with 40 form 2 students. Teachers who had a teaching experience of over 5 years were considered and inducted on how to use the method.

2.4.3 Effect of PBLS on Girls' Motivation towards Physics

Njoka (2020) defines motivation as efforts in which learners put into learning as a result of their need or desire to gain knowledge. The expression motivation to study is defined by Georgouli (2002) as the state or measure of being meaningful. An interesting classroom environment is very important in ensuring successful and fruitful learning which in itself requires creativity in designing teaching strategies. A student who is intrinsically motivated undertakes an activity for its own sake, for the enjoyment it provides, the learning it permits or the feeling of accomplishment it evokes (Devika, 2020; Ratcliffe & Tokarchuk, 2020). On the other hand, learners who are extrinsically motivated carry out assignments so as to get reward or avoid punishment from teachers (Meghesli & Ghania, 2021). These findings suggest that when the teachers capitalize on existing intrinsic motivation, there are several potential benefits. That it is important that the teachers try to convince their students that learning rather than grades is the purpose of academic work. This can be done by emphasizing the interest value and practice of the material that the students are studying and by de-emphasizing grades and other rewards so that intrinsic motivation is emphasized.

Learning is not only supported but also enhanced through positive effective factors such as interests, motivation, attitude, belief, self-confidence and self-efficiency, Girls with a belief in their own abilities and value attribute their learning tasks as being significant predictors of their final success. A girl is more likely to desire to learn when she appreciates the value of the classroom activities and the believe that they will succeed if they apply reasonable efforts (Jiang, Chen &Wu, 2021). In addition, motivational belief can influence the process of learning and conceptual changes (Wong & Wong, 2021). This motivation is usually context specific and relies strongly on the classroom situation. Girls need to believe that they are capable of performing a task, that they have some control over the task and that the task is achievable.

The beliefs that the teachers themselves have about teaching and learning and the nature of the expectations they hold for students also exert a powerful influence. Sigh, Granville and Dika (2002) pointed out that to every large degree, students expect to learn if the teachers expect them to learn. That it is important for teachers to communicate positive expectations for their students, that they can learn the material presented to them. Some of the strategies and factors that may be employed to motivate girls and stimulate them to learn include; first teachers providing a supportive environment and establishing a trusting bond since motivation is natured by the teachers in every learning situation. Secondly, teachers should help girls recognize links between efforts and outcomes. Learning is a long-term plan of effort and investment. Thirdly, the teachers should breakdown learning steps into digestible pieces and minimize learner performance anxiety during learning activities.

Students' incentive affects significant Physics learning: specifically, if incentives are directly linked to higher level of thinking (Njoka, 2020). Most of research literature indicates notable relationships between learner's motivational viewpoints and their mental processes (Phan &Ngu, 2021). A range of factors have an effect on learners' intrinsic motivation such are those that involve them in classroom tasks considering their welfare, wants, goals and viewpoint regarding their potential and expectations that improve their self-worth (Larner, 2020).

If girls believe in their own capability towards a task, they can use high order thinking skills. Furthermore, achievements develop motivation. Robinson (2019) ascertains that learners motivation depends on three factors; first is the feeling of worth, secondly, is the observation of efficiency and thirdly, is one's positive emotive reply to the information component.

The conditions that must be satisfied for an activity to qualify to be intrinsically motivating, according to (Ng & Chu, 2021) are; first, it has to have a suitable degree of confront, then have important and genuine tasks for learners; and then offer learners opportunity for educational criticism and recommendation; a task devoid of previous obstacles as well as constraints. Students perform in their own free will and point of reference in appraisal is not based on content, neither on comparison, but on individual evaluation in learning physics.

It is assumed that a stable classroom environment is necessary for intellectual growth and the introduction of the expression of investigations alleged to improve learners' motivation for Physics learning. More student-centered strategies with many student discussions in experiments are needed to engage students in meaningful learning; Aksela (2019). Real-world problems motivate and help to encourage transfer of knowledge and skills, by encouraging students to apply their knowledge. This therefore emphasizes the need to embark on PBLS in order to enhance problem solving, critical thinking and motivation towards physics learning. Kanyesigye, Uwamahoro and Kemeza (2022) investigated the impact of problem-based learning strategy on learners' attitudes in learning physics in Uganda. The study sampled 419 grade12 learners undertaking physics in both public and private secondary schools. Using quasi-experimental approach with cross-sectional survey technique, two groups of students were exposed to learning for 12 weeks. The control group was subjected to conventional teaching method while the experimental group was treated with PBL method. Data was collected using 'views About Science Survey Tool' and analyzed using both descriptive and inferential statistics. Results showed that the experimental cohort acquired more positive attitude as compared to control cohort. The study resolved that PBLS was effective in the instruction of physics as a subject as compared to the conventional teaching methods with approximately 20% gain in attitudes. Therefore, teachers were advised to use PBLS in relaying abstract terms and concepts in STEM in secondary schools.

Although Kanyesigye, et al (2022) did not align their study on any specific topic in physics, the current study attempted to examine the effect PBLS had on girls' motivation, in the topic of Fluid Flow which is taught at form 2. The study showed that all students were motivated with the physics lessons, and understood physics problems and calculations and abstract terms with ease through exposure to PBLS. The positive regression weights obtained showed that teachers use of PBLS improved girls' motivation in learning physics as a science subject, which was a pointer to enhanced enrolment in physics at form three.

2.4.4 Learner's Ability to Illustrate Experiments using Problem-based Learning Strategy

The use of class experiments in teaching and learning enhances critical thinking skills among students. An experiment refers to set of activities and observations, that are performed to solve a specific question or problem, or to determine or alter the hypothesis concerning certain phenomena, emanating from specific theory. Students find certain concepts or theories difficult to comprehend when taught in normal theory or lecture. Experiments are very prominent in teaching and learning. However, learners seem to have an inherent obligation to learn such abstract terms and then relate them to the existing issues. The students will easily remember the experiments because they are used to introduce new concepts/ideas or rather clarify confusing aspects of the topic. One area where these experiments often succeed is in the STEM subjects, particularly Physics, as in the topic of fluid flow among others.

Due to globalization and technology, the world today demands more skills and knowledge through experimentation. (Zhao., He., Deng., Zhu., Su., & Zhong, 2020) claim that learners who are involved in experiments significantly perform better in tests whereas researchers such as Saleh, Phillips, Hmelo, Glazewski, Mott, and Laster (2022) point to the potential difficulties involved in performing experiments. They suggest that learners must be guided in experiments to provide them with scaffolds and heuristics. This essay examines evidence of learners' ability to demonstrate experiments.

Tambunan (2019) conducted a randomised study on the effectiveness of the PBLS and the scientific approach among students undertaking Mathematicsin in Indonesia. The study sampled grade 10 students from both public and private high schools. It employed quasi experiments using experimental ($n = 138$) and control ($n = 139$) groups. Two classes from the public schools and two from private were then subjected to an essay test on the topic of linear equations which evaluated creativity, communication, mathematical reasoning and problem solving using random sampling techniques. The results showed that learning through problem solving strategy was statistically significant than the scientific approach to learners' mathematical abilities in communication ($t=8.50$, $p < 0.025$), creativity ($t=11.743$, $p<0.025$), problem solving (11.447, $p< 0.025$), and mathematical reasoning ($t = 11.754$, $p<0.025$). It was concluded that PBLS was more effective than other approaches like the scientific approach in gaining critical skills.

A randomized study was conducted by Kanyesigye, Uwamahoro and Kemeza (2023) on the effect of PBLS on learners' achievement in the topic of mechanical waves among secondary schools in Southern -Uganda. The study used a quantitative research design with a quasi-experimental convergent parallel design employing cross-sectional survey techniques. They randomly sampled 419 Form 6 physics learners in 19 schools. The pre-test and post-test in the use of PBLS in the control and experimental groups was administered using Solomon's four-group design. Results show that learners performance improved significantly in the topic of electromagnetic waves when PBLS was used, with greater effect sizes and high knowledge gains in experimental than control groups. Similarly, Ogweno, Kathuri and Nkurumwa(2021), conducted a comparative study on the effect of PBLS and demonstration technique on learners achievement among form 2 Agriculture students in Ndhiwa Sub-county, Kenya. They targeted 12 schools with a sample of 575 learners and 12 instructors using quasi-experimental approach. Half of the target schools used PBL as experimental group and the remaining half were taught using demonstration method as control. Both experimental and control groups were given pre-test, and a post-test was administered after 6 weeks of learning. Agriculture Achievement Test tool (AAT) was used to collect data and analyzed descriptively using analysis of covariance (ANCOVA).

Results show that the achievement in performance was higher by 18.7% (mean increase of 9.07) compared to demonstration method. They found statistical difference in the post-intervention performance scores in the two interventions, $F(1, 278) = 1170.43$, $p < .001$.

The findings of the present study were in complete agreement with the findings of the researches done above, however, on use of PBL on girls' ability to describe experiments that illustrate Bernoulli's effects in nature, the study found that PBLS improved learners critical thinking skills, which in turn improved achievement and performance in physics.

Physics and other related science subjects are critical in development of Science, Technology and Innovation (STI). However, the traditional teaching methods characterized by rote learning employed in the teaching of the subject does not foster critical thinking, creativity, problem-solving skills and a holistic learning environment among learners. Physics is sometimes taught in such a way that concepts are largely removed from everyday life of leaners and real-life application. One way to address this scenario is to use PBL which advocates for learner-centered approach in teaching, since it is concerned with designing lessons that give learners opportunity to solve real life problems contextualized in respective subject content.

2.4.5 Constructivism Theory in Learning of Physics

Constructivism is an approach to learning that hold that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner. Jean Piaget is one of the proponents of this theory (Piaget 1950). Recent changes in teaching and learning processes have had their roots in the two broad theoretical developments. The first is, the field of psychology, which has the work of behaviorism, based on the foundation about the work of the brain. This theoretical approach proposes that the actions of people and how they respond to stimuli can merely be learnt (Adebayo, 2019). The result of this idea is that there is an inflection on strategies such as recurrence that support "parrot" approach to learning rather than advanced order cognitive processes. The cognitive psychology faction surmises that the person's reaction to stimulus is personal and depends on the person's cognitive condition and on the intellectual processes taking place. Social constructivism was developed by Vygosky, who argued that learning is a social and collaborative activity where people create meaning through their interaction with one another (Schreiber and Valle, 2013). Students create ideas through interactions with the teacher and other students.

The second theoretical view, termed as the constructivist view is one with the focus of teaching based on guiding the learner as they construct on and adjust their existing rational models that are a focus on knowledge building rather than knowledge transmission (Saunders & Wong, 2020; Tu, 2023). The consequences of the constructivism theory are two-fold;

a) The focus is on the learner in thinking about learning (not on the subject/ lesson to be taught)
b) There's no knowledge independent of the meaning attributed to experience (constructed) by the learner, or community of learners. This is what was proposed by Dewey, Piaget and Vygotsky. They have a view that there's no such a thing as knowledge 'out there', independent of the knower, but that knowledge we construct for ourselves as we learn.

Principles of constructivist learning are varied and may involve:

a) Learning as an active process in which the learner uses sensory input and constructs meaning out of it.
b) People learn to learn as they learn. Learning consists of both constructing meaning and constructing systems of meaning.
c) The crucial action of constructing meaning is mental; it happens in the mind. Physical actions, hands-on experiences may be necessary for learning but not sufficient. That we need to provide activities which engage the mind as well as the hands (Wang, 2020).

From the principles above, we can agree that learning through cognitive apprenticeship, mirroring the cooperation of real-world problem solving, and using the tools available in problem solving situations is important. The effective learning of physics starts with the teacher knowing the prior knowledge of the learner. The physics teacher should know what experience the students had on the concept to be discussed.

This knowledge will determine the teachers approach to the instruction. One of the reasons for mass failure in physics is because many teachers come to class to start lecturing without considering students' entry behavior. Most students cannot link the new information given by the teacher with what they already know. Thus, confusion sets in and to resolve this confusion many learners' resorts to memorization. Memorization is not a good way of authentic learning (Aina, 2017), (Njoka, 2020).

Students learn effectively in physics if the teacher gives the students maximum chance for social interaction. Many of these students had something in mind before coming to class, during the interaction the students would be able to resolve many of the pre-conceived wrong or right knowledge within themselves by the help of the teacher. Research studies show that teacher strategies of instruction often hinder physics students from learning effectively (Oladeyo, Olosunde, Ojebisi and Isola, 2011; Wambugu, Changeiywo, and Nderitu, 2013). To this end, a physics teacher must therefore have the good content knowledge and sound pedagogical knowledge. A constructivist teacher therefore should modify their instructional strategies to best suit the students thought process, experience and/or interest. How effective or instrumental the learner's knowledge structure is in facilitating thinking in the content fields is the measure of learning (Orodho, 2003).

2.4.6 Knowledge Gaps in Reviewed Literature

Performance in key science subjects in the curriculum, like physics has not been satisfactory in Kenya over time especially among girl's sub-county schools. Many studies which have been done revealed reasons as to why we have had dismal performance in this subject, (Katiambo, 2019). Issues of gender difference, poor or negative attitudes, shortage of professional teachers, poor foundation in mathematics at primary school which form the basis of the subject at secondary school, irregular in-service training of the teachers and lack of self confidence in the learners among others, have been identified as the key causes of the poor performance in the subject.

Most of such studies were done in either developed countries, or in other African Countries, However, little has been done on the 'use of learner-centered teaching strategies in the classroom' to possibly help alleviate the problem of low enrollment and performance in physics at KCSE level, in sub-county girls' schools in Bungoma-Kenya. With learner centered strategies, learners are encouraged to take the center stage in their own learning. PBLS is one of learner centered teaching methods, which is a paradigm shift from the traditional teacher-centered classroom to learner-centered. In this type of instructional approach, the learner is in charge of the learning process with the teacher as a facilitator of the learning, it is this reasoning that necessitated this study to be conducted in Bungoma County, an area that has been posting declining performance in physics in sub-county girls' schools, to probably try to alleviate this problem.

2.4.7 Research Gaps

Prior studies recognize the use of science-based process skills to develop learners in finding scientific information, develop critical skills such as solving problems and making decisions to improve creativity and perception towards STEM subjects (Irwanto, et.al., 2019; Limatahu, et. al., 2018). They claim that such skills should be considered at early years and developed continuously in the learner's lifetime (Çakiroğlu, Güven & Saylan, 2020). Acquisition of such skills require development and implementation of educational policies. Such policies evolve over time, and sometimes the policies are non-specific that more often leads to failure during implementation.

Over the past decade, the educational reforms through policy were adopted by the Government of Kenya but are yet to bring out intended output and the future seems wanting especially with the enrolment and performance of girls in science-oriented subjects. While the education policy advocates revision of the curriculum to be competency based and ensure gender parity in education; the use of alternative modes of curriculum delivery is seen as a feasible method to implement this policy.

The Ministry of Education acknowledges that secondary school curriculum needs to be reformed to shift from knowledge reproduction to knowledge production. However, Njoka (2020) and Bett (2022) have pointed out that research on all the teaching strategies practiced in Kenyan schools are mostly expository and facts oriented, making students to be passive.

Similarly, constructivism theory in learning has not been fully utilized hence teaching and learning of Physics especially the girls have consistently registered low enrolment and poor performance issues. This study unpacked the literature gaps exploring how problem-based learning strategy may influence learner performance in the context of physics curriculum among girls in secondary schools in Bungoma County, Kenya.

Likewise, this research incorporated the constructivism theory of learning model to illustrate how PBLS is useful in the implementation of public policies such as the education policy in realization of skill development in the county.

2.4.8 Summary of the Literature Review

In all the literature reviewed in this study, there is near consensus on the need to transform and modernize the way we are teaching the next generation. Locally, not much has been done in terms of concretizing this desire in the classroom. (Njoka, 2020), has pointed that the quest for better teaching strategies has been on-going to fill the gap of academic achievement gains. Both Njoka, (2020) and Bett, (2022) attribute that most teaching strategies practiced in Kenya are expository and facts oriented making students to be passive.

More so girls' motivation and achievement are enhanced when co-operative learning is used. Discovery learning leads to problem solving skills and increase girls' confidence in their learning and the ability to adapt to the real world (Njoka, et al., 2021).

Teaching requires that teachers use methods that are unique to the content being taught. The learner is central to learning, thus teachers need to involve them actively in their own learning and make connections between what they learn and what they already know. The teachers therefore have a task of bridging the gap between what a student already know and what they are expected to know by utilizing the problem-based learning strategy to address the achievement gains. Wafula (2017) argues that the curriculum and the syllabus remain boring if not converted into exciting and interesting episodes by the teacher using the right teaching methods. As a result, there's need to improve the teaching strategies in Physics subject. Through interaction of PBLS in teaching, gains in problem solving and critical thinking abilities, motivation towards Physics among the sub-county girls, was investigated in Bungoma County, Kenya with the aim of filling this knowledge gap.

CHAPTER THREE

RESEARCH DESIGN AND METHODOOGY

3.1 Introduction

In this chapter, a description of the research was given. The target population, sampling procedures, sample size and the data collection instrument that was used in this study was specified. The chapter summed up with data collection procedures as well as statistical methods that was employed in data analysis.

3.1.2 Study Location

The study was conducted in secondary schools in Bungoma County. Bungoma County borders the Republic of Uganda to the West, Busia County to the South West, Trans-Nzoia, and Kakamega to the North-East.

The county has an area of 2,206.9 square kilometers and lies between 1,200 and 1,800 meters above sea level. Its latitudes stand at 0.57 with the longitudes of 34.56 (co-ordinates: 0.5695^0N, 34.5584^0E) (Appendix VII). The population of Bungoma is estimated at 1,670,570 of which 812,146 were males and 858,389 were females as per the 2019 census. The region has a population density of 760 people per sq. km. The economy of Bungoma County is mainly agricultural, centering on the sugarcane and maize industries. Poverty level index stand at 53% while dependency level ratio is at 93.8 with a national percentage of 3.6%. The County was selected because of the performance in KCSE Physics which has persistently recorded a low mean score in Girls sub- county schools over the years. The county has many boys' and girls' secondary schools as well as mixed schools with a large number of trained teachers in all subject areas.

There are a total of 385 secondary schools. The main university in the area is Kibabii University, which was chartered in 2015. It is a public University along Chwele Kimiili Road. Masinde Muliro University of Science and Technology (MMUST) has campuses at Bungoma and Webuye. Other major educational institutions of higher learning include Sacred Training Institute (STI), Sang'alo Institute of Science and Technology, Kisiwa Technical Training Institute, Matili Technical Training Institute, Bungoma North Technical and Vocational College and Kibabii Diploma Teachers College.

Nzoia Sugar Company is the main industry in the county that manufactures sugar and sugar products. It is located in Bungoma South Subcounty, 5 km from Bukembe. Pan-paper Industry in Webuye produces paper and other related products.

3.2 Research Design

A research design gives a guideline or framework that enables a researcher to raise appropriate answers to the study questions. It is a blue print of the procedures that enable the researcher to test his/her hypothesis by reaching valid conclusions about relationships between independent and dependent variables (Key, 1997). This study adopted Quasi-experimental research design. Leedy (1997) pointed out that one of the greatest advantages of research studies that use experimental design was that they could be replicated more than once using different groups of subjects, and their findings validated to help confirm generalizations and that random selection of participants ensured good internal validity. Since a true experimental study was not ethically and practically possible due to the researchers' inability to achieve a perfect random assignment of participants to the experiment and control groups, the researcher adopted a quasi-experimental design for the study. Kothari, (2004) describes quasi-experimental design as one aiming to identify the cause-and-effect relationship between two variables; the independent and dependent variable. Quasi experiment design employs non-random criteria while assigning subjects to groups. The study adapted a nonequivalent Solomon Four Group Quasi-experimental research design. In this type of design, the researcher used four groups. Two groups were treated as they would be in a classic experiment-pre-test, experimental intervention, and then post-test. The two other groups did not receive the pre-test, though one received the intervention. All groups were then given the post-test. Non-equivalent groups were used because classes in secondary schools once constituted existed as intact groups. The school authorities do not normally allow such classes to be broken up and reconstituted for research purposes. Fig. 2 shows Solomons four group, non-equivalent control group design

Group 1 0_1 X 0_2 Experimental group

Group 11 0_3 0_4 Control group

Group 111 X 0_5 Experimental group

Group 1V 0_6 Control group

Figure 2: Solomon's Four-Group, Non-equivalent Control Group Design

KEY

X- treatment
O-observation (pre-test or post-test of dependent variable)
0_1 and 0_3 – pre-tests
0_2, 0_4, 0_5 and 0_6 – post-tests

------Dashed lines show that the experimental and control groups were not equated by randomization, hence non-equivalence.
Source: Cohen and Manion (2005), Gall. Borg & Gall (1996) and Wiersma and Jurs (2005)

Thus, it was possible to assign class randomly as required in true experimental designs. Of the eight girls' school that were chosen, four were assigned to the experimental group and four to the control group through simple random sampling. The schools selected were however, assigned to the treatment and control conditions as intact groups. The quasi-experimental design was deemed appropriate for the study because it allowed for assessment of problem-based learning strategy.

Solomon Four control group Quasi-Experimental designs was deemed appropriate for this study because it was considered vigorous for both Experimental and Quasi-experimental studies (Borg & Gall 1989). The design helped the researcher achieve three purposes: to assess the effect of the experimental treatment relative to the control condition, to assess the interaction between pre-test relative to the post-test and; to assess the homogeneity of the groups before administration of the treatment.

Quasi-experimental research design procedure controlled all major threats to internal validity except those associated with interaction of selection and history (the specific events which occurred between the first and second measurement), selection and maturation (selection of comparison groups and maturation interacting which may lead to confounding outcomes, and erroneous interpretation that the treatment caused the effect) and Selection and instrumentation (the changes in the instrument, observers, or scorers which may produce changes in outcomes) (Cook and Campbell, 2000: Mugenda and Mugenda, 2003).

To control for interaction between selection and maturation the schools were randomly assigned, to the control and treatment groups. The conditions under which the instruments were administered would also be kept as similar as much as possible across the sample schools to control for interaction between selection and instrument. The teachers who gave the intervention were inducted on how to administer the treatment. They used schemes of work for four weeks of teaching then administered a post test. An instructional guideline for teachers in the study based on the Physics syllabus was constructed and used to induct teachers on how to use the schemes of work and give the treatment. A manual was prepared and was used by the teachers in the experimental groups to ensure that there was uniformity in exposure of students to the interventions. A manual provided teachers with a collection of activities that could be directly implemented hoping that the examples and resources provided would spark the ideas of teachers to develop further activities and share them with colleagues.

All the teachers involved in the study adopted a common scheme of work on the topic of Fluid Flow; which ensured that the intended content was covered uniformly by all groups involved in the study.

3.3 Research Philosophy

The study adopted pragmatist philosophical view in research. The pragmatic paradigm refers to a worldview that focuses on “what works” rather than what might be considered absolutely and objectively" true" or "real", thus it adopted a flexible approach to solving the research problems. Pragmatism is defined as an approach that evaluates theories or beliefs in terms of the success of their practical application. It involved research designs that incorporate operational decisions based on what 'will work' in finding answers for the questions under investigation and thus enables pragmatic researchers to conduct research in innovative and dynamic ways to find solutions to research problems.

In this study PBLS as a teaching strategy was hoped to have its effectiveness judged when there would be improved or non-improved academic and motivation gains in the sampled group of learners in Physics (Fluid Flow) as per the research objectives under study. A pragmatist can consider something to be true without needing to confirm that it is universally true.

3.4 Target Population

As defined by Frederic (2010), is a universal set of the study of all members of real or hypothetical set of people, events or objects to which an investigator wishes to generalize the results. The target population in this study were public girls' secondary schools in Bungoma County and accessible population was all form two physics girls in all sub-county girls' schools. The form two girls were selected because the topic of Fluid Flow is taught at this level.

In year 2019 total schools established with classes running from form one to form four in Bungoma County were 342 where 2 were national schools; 37 boys only,57 girls only and 248 mixed schools. Form 2 students tallied to about 6180 students in these sub-county girls' schools. There were seventy-eight teachers of physics in these schools. Eight teachers from eight schools each with five years of teaching experience participated in the study. The County was chosen because of its poor performance in KCSE results in Physics among girls in sub-county girls' schools and the low enrolment in Physics, as a subject compared to that of Biology and Chemistry. However, the findings of this study could be applicable to any other counties that also posts poor results.

Since the county posts poor results, the researcher decided to carry out the research in Bungoma, because of its accessibility. Singleton and Straits (1999) observed that the ideal setting of any study is one that is directly related to the researcher's interests and easily accessible. Since research required careful thought about a number of practical factors, accessibility and cost factors became legitimate considerations when deciding on a study location. Needless to say, this research could still have been carried out in any county that posted similar poor results in physics.

3.5 Sampling Techniques and Sample Size

According to Mugenda and Mugenda (2003), sampling is the process by which a relatively small number of individuals, objects or event is selected and analyzed in order to find out something about the entire population while sample size is the total number of respondents included in a study.

The research used stratified random sampling to select the eight schools that participated in the study, all of which were girls' sub-county schools. Bungoma County has nine sub-counties and therefore to ensure equal representation from each subcounty, the researcher grouped all the sub-county girls' schools from each sub-county, (except Webuye East and West that were treated as one subcounty) into one stratum, giving rise to eight strata. From the eight strata so formed, one school was randomly selected, using small pieces of paper on which the schools' names were written. The researcher mixed these papers and at random picked one paper on which the school's name was written to participate in the study. This ensured that at least one school from each subcounty was included in the final sample.

Simple random sampling technique was then used to group four schools to experimental and four others to control group through simply picking the first four papers with the school's name to be used as control while the remaining other four papers with the school's name to experimental group. Where schools had more than one stream all participated but simple random sampling was done to select one stream of n= 40 for data analysis.

The selection of eight girls' schools was deemed necessary to avoid excessive stratification that could result in complexities stemming out of logistics involved in handling many school types, especially in a quasi-experimental design (Cohen, Manion &Morrison., 2000). The success of experimental and quasi-experimental designs normally relies on stringent control of extraneous variables (Fraenkel and Wallen, 2000). A challenge that was minimized by reducing variation in characteristics of groups involved. A total of 320 students from eight schools participated in the study as shown in Table 4

Table 4: Categories of Schools and Number of Respondents

	GROUP TYPE	NUMBER OF RESPONDENTS		TOTAL
I	Experimental	40	40	80
II	Control	40	40	80
III	Experimental	40	40	80
IV	Control	40	40	80
TOTAL		**160**	**160**	**320**

3.6 Research Instruments

The research used a number of instruments, including Physics Achievements Test (PAT), Observation Schedule, and Motivational Questionnaire.

3.6.1 Physics Achievement Test

To determine academic achievement from integrating of PBLS in sub-county girls' secondary schools, a Physics Achievement Test (PAT) was developed for the research on the topic of Fluid Flow from the Physics syllabus. Two tests, a pre-test and a post-test were used (Appendix II). The pre-test consisted of questions that were set based on the objectives of the study by the researcher; which were also the same objectives to be achieved by the learner as per the approved KICD New syllabus.

The pre-test had five structured physics questions which covered the derivation of the equation of continuity, the gain in problem solving abilities of the learner and the ability of the learner to apply the knowledge gained to real life situations. The researcher together with the teachers of physics in the study schools set the questions and sat together to moderate the questions and moderate the marking schemes. The setters utilized the syllabus objectives, schemes of work and learner text books on the topic of fluid flow. The test was to be administered in one and a half hours by the physics teachers in their respective schools, (see Appendix II). After the four weeks of exposure to the PBLS by the teachers in experimental schools and normal teaching in the control schools, a post-test was applied to both the experimental and control groups.

The post-test consisted of similar structured questions on the topic fluid flow, testing the same objectives and with a duration of one hour and thirty minutes. However in this test, the learner was provided with either a smartphone or laptop to visit the link that was provided and watch a video before proceeding with answering the question on objective one, (see Appendix II). Other questions for the remaining objectives were to be answered by the learner carrying out stipulated hands-on activities whose apparatus had been provided by the teacher. The learner was then expected to apply the learnt concepts in the remaining questions which required application. The purpose was to provide a common measure to assess girls' performance in the control and experimental groups.

3.6.2 Observation Schedule

Observation schedule which was designed to reveal patterns of either teacher or student behavior was used to observe lessons on the topic Fluid Flow to provide data on teacher and learner activities during instruction processes. It had two sections that provided data on the teachers and learners' activities during the lesson respectively. Observation method was used because certain types of information were obtained best through direct observation by the researcher. The data obtained from observation was very reliable because it was first-hand information (Meredith, 2007).

In this study, Physics lessons were observed to get first-hand information on how the gains in problem solving abilities in integration of PBLS in teaching and learning were enhanced during the teaching and learning process. The observation was about planning of a problem-based learning investigation, data analysis, synthesis and conclusion. The observation form was pilot tested in Busia and was found to be effective for data collection. Data from observation schedule was analyzed descriptively in the next chapter.

3.6.3 Motivational Questionnaire

A questionnaire which consisted of a written list of questions which had been pre-tested in two schools in Busia County and found to be effective, was introduced to both control and experimental groups in the fourth week of teaching. The required information was extracted from the answers as were given by the respondents (Mugenda and Mugenda, 2003). Use of questions could reach a large number of people who were able to read and write independently (Rahi, Alhaser & Ghani 2019). The constructed questionnaire used a Likert scale as a rating scale to facilitate data collection.

3.7 Piloting Study

Malmqvist, et. al (2019) and Roni, et. Al (2020) observe that piloting is important as it helps identify misunderstanding, ambiguities, and inadequate items. The study carried out piloting of instruments using two secondary schools with the same characteristics as sampled schools and was done in Busia County. During the pre-testing, the instruments were administered to all form 2 physics students in the two schools that were identified. The instruments were found appropriate for use for the intended study.

3.7.1 Validity

Validity is the degree in which results obtained from the analysis of the data actually represent the phenomenon under study Mugenda & Mugenda, (2003); Cohen, Mannion & Morrison (2000), or simply put, validity refers to how well an instrument measures what it is intended to measure. There are four types of validity: content validity, criterion-related validity, construct validity, and face validity. Validity is largely determined by the presence or absence of systematic/non-random error as a result of the measuring instruments. Validity of the instruments in this study was improved using a judgment by experts and the researcher's supervisors. The questionnaires and observation schedule were presented to the experts on the topic of study from the school of education, University of Eldoret for the purpose of checking face and content validity. Their advice was used in the revision and modification of the instruments before they were finally used in the study,

The university supervisors of this study reviewed the research tools for clarity, readability and comprehensiveness then together with the researcher agreed on the items that were included in the final instruments. Face validity of PAT was achieved by presenting the items to specialists in the Department of Educational Communication and Technology. The items showed a relationship between the construct and predicted outcome. On content validity of PAT, the test items were taken to Physics teachers in secondary schools under study to judge their viability and the extent to which the test items were appropriate as a representative sample of the entire content that the test items were designed to measure. The content review committee worked with the researcher to review each item based on a strict criterion before the items could be field -tested. After the test items were field-tested, the content review committee reconvened to review the items using the field test statistics. Their views were incorporated in the final tools before they were administered to the sampled schools.

3.7.2 Reliability

Reliability is a measure of the extent to which a research instrument yields consistent results after repeated trials (Borg and Gall, 1986). The instruments were pilot tested in two schools that were not part of the study. Reliability coefficient was determined using Kunder-Richardson (KR- Formula 20) estimates. KR- Formula 20 as an estimate of reliability was appropriate because it required less time since it was administered once and provided the mean for all possible split half coefficients (Gay, 2003; Wiersma and Jurs, 2005). The KR-Formula 20 was adapted for use (Sattler, 1988) for objective 1,2,3 and 4 together with Cronbach's Alpha coefficient to determine the reliability of the study tools. This aspect of reliability was confirmed by correlation coefficient on a rating of up to 1 and taken at correlation coefficients of or equal to 0.70. and 0.75 for Cronbach's Alpha and K20 correlation respectively. Thus, the coefficient >0.70 and >0.75 was considered desirable. Table 5 shows the findings of the reliability coefficient.

Table 5: Item-Total Statistics for K20 and Cronbach's Alpha Reliability Coefficients

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Objective 1	11.3250	10.328	.887	.916
Objective 2	9.8250	11.276	.672	.932
Objective 3	11.4750	11.538	.824	.925
Objective 4	11.5250	11.948	.756	.930

Test to observe if data from the five objectives met the assumption of reliability based on K20 and Cronbach's Alpha show that the tools were highly reliable (K20 and Cronbach's Alpha = 0.925 and 0.921 respectively).

3.8 Data Collection Techniques

The data collection process began with the researcher obtaining a proposal approval letter (Appendix VIII) from the School of Education, University of Eldoret. The letter enabled the researcher obtain a Research Permit (Appendix XI) and a Research Authorization Letter from the National Council of Science Technology and Innovation (NACOSTI) in Nairobi. These documents enabled the researcher to obtain permission to conduct academic research in the county from both the County Director of Education, and from the County Commissioners office, Bungoma County to carry out research in the sampled schools in the county.

The researcher collected data in person. To facilitate this exercise, an introductory letter (Appendix I) to the schools was done under the guidance of the researcher's university supervisors and was presented to the principals of the eight sampled schools during the pre-visit. The researcher sought permission of headteachers and teachers of physics to conduct the research. Two days were used for these visits, which were also meant to help the researcher disclose the intention of the study to the subjects and create rapport. The physics teachers were then inducted for one week on how to use PBLS. This enabled them to master the skills of using PBLS as a teacher's strategy.

After this period, timetables were collected from the teachers concerned with the aim of making a visiting schedule. This was necessary in order to know which teacher to observe and at what time. The sampled schools were assigned to the experimental and control groups by simple random sampling.

A PAT pre-test was administered to experimental group 1 and control group 2 by the researcher being assisted by the physics teachers. Throughout the study, the experimental group was exposed to a series of lessons on the topic Fluid Flow using PBLS treatment. The control group was exposed to the same content using their normal classroom practices. The researcher therefore observed a series of lessons in all the groups.

After the treatment period, the researcher was assisted by the Physics teachers in the sampled schools to administer a PAT post-test to all four groups. Details of the results are presented in the next chapter. The researcher scored and coded the collected data and the Statistical Package for Social Sciences (SPSS) software applied to it for analysis.

3.9 Data Analysis

The data was scored, coded and organized for analysis. Data was analyzed using both descriptive and inferential statistics. Raw data was analyzed using means, standard deviation and percentages so as to meaningfully describe the distribution of the measurements from the SPSS 26.0.

3.10 Logistical and Ethical Consideration

Before proceeding for data collection, the researcher visited the County Director of Education and the County Commissioner offices for permission to be allowed to carry out education research in the County. Before visiting the selected schools, the researcher sent letters to the principals requesting to be allowed to conduct the research in their schools. The letters were sent in person for immediate feedback. While in the schools, the researcher obtained consent from the respondents to participate in the study and assured all of them of confidentiality. The respondent’s identity was further concealed by advising them not to write their names and the names of their schools on the test papers. The names of the sampled schools were coded to hide their identity and assurance given to the principals that information collected was only to be used for the purpose of research, and was treated with utmost confidentiality. The researcher, however, assured the respondents that the research findings would be shared through educational forums and publications.

3.11 Chapter Summary

The research was conducted in Bungoma County which borders with neighboring Uganda to the West and other Counties- Busia, Kakamega and Trans-Nzoia. The County has a high dependency ratio and academic enrolment and performance in physics at KCSE among the girl-child, is low and poor.

The study adopted a quasi-experimental design and adapted a nonequivalent Solomon Four Group Experimental design. Pragmatism philosophical view was adopted as it was a flexible approach to solve the research problem since its operational decisions were based on what worked in finding answers to questions under investigation and therefore encouraged innovation in research in a dynamic way.

The research targeted all the sub-county girls' schools in Bungoma County and sampled 8 schools using stratified random sampling. A total sample of 320 form 2 students were used and were assigned to experimental and control groups.

The research instruments consisted of Physics Achievement Test (PAT), Observation Schedule, and motivational Questionnaire. Piloting of the instruments was done prior to data collection in neighboring Busia County and were found to be reliable. Data was collected and analyzed using both descriptive and inferential statistics. The information obtained was treated with outmost confidentiality

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSSION OF THE FINDINGS

4.1 Introduction

This chapter deals with data analysis, presentation and interpretation of the research findings. The study aimed at investigating the effect of PBLS on students' achievement in physics using the topic Fluid Flow in sub-county Girls' secondary Schools in Bungoma County, Kenya. The study sought to achieve the following objectives;

a) To determine girls' ability to derive the "equation of continuity" in physics (Fluid Flow) when using Problem Based Learning strategy.

b) To determine problem solving abilities of girls in physics (Fluid Flow) when using problem-based learning strategy.

c) To establish effect of problem-based learning strategy on girls' motivation towards "Fluid Flow" as compared to conventional teaching methods

d) To determine ability of girls to describe experiments to illustrate Bernoulli's effects in nature when using problem-based learning strategy.

4.2 Ability to Derive the "Equation of Continuity" in the topic "Fluid Flow" when using PBLS

The study purposed to investigate whether girls are able to derive the "equation of continuity" in the topic "Fluid Flow" when using Problem Based Learning Strategy. The eight girls' schools were coded as A1, A2, B1, B2, C1, C2, D1 and D2 for the groups where 1 represented the control group while 2 represented the experimental groups. Results are given in Table 6.

Table 6: Descriptive Statistics on Ability to Derive Equation of Continuity in the topic of Fluid Flow using PBLS

Schools	N	Min	Max	Mean	Std. Dev.
A1	40	.00	3.00	.7500	.95407
A2	40	2.00	5.00	3.1000	.92819
B1	40	.00	2.00	.6250	.77418
B2	40	.00	4.00	1.6250	1.33373
C1	40	.00	4.00	1.5500	1.33877
C2	40	.00	5.00	3.0500	1.35779
D1	40	.00	5.00	1.8000	1.60448
D2	40	.00	3.00	1.7250	.98677
ValidN (listwise)	**40**				

As shown in Table 6, the performance of the Girls in school A2 and C2 was better at (M = 3.1, SD = .92819) and (M = 3.05, SD = 1.35779) respectively, than schools B2 and D2 after the exposure to PBLS in the same topic. It should be noted that all the girls in those study schools performed poorly before the exposure to PBLS. On average experimental scores for school A2 were 2.35 points higher than control scores illustrating a 76% improvement in the performance of the girls. However, the experimental mean scores for school D2 were lower by 0.075 than control score in the test performance for the Girls. The variation of school A2 and D2 could have been attributed to by the teacher’s year of experience and exposure with the use of PBLS. These findings demonstrate that the PBLS has greater influence on Critical Thinking as a method of teaching and learning when appropriately used by the teachers. Science subjects are practical oriented and for effective skill development among the learners, it requires learners to demonstrate practical competence. Despite the fact that the performance among the girls after exposure to PBLS was not homogeneous, the acquisition of critical thinking skills varied immensely due to environmental factors such age, socio-economic factors, nature and type of school, and organization culture.

The study further tested the $Ho_{1:}$ That there is no significant difference in achievement scores in ability to derive “equation of continuity” in the topic Fluid Flow between Girls who are exposed to problem-based learning strategy and those who are taught using conventional methods. A total of 80 students were randomly assigned to either the experimental group (n=40) or the control group (n=40) in each of the four Girls’ school in the study area. The experimental group received training using PBLS, while the control cohort received no intervention or were rather exposed to conventional teaching method. A paired samples t-test was performed to compare the test performance between exposed and non-exposed group.

Table 7: Results for Paired Sample Statistics on Ability to Derive Equation of Continuity

		Mean	N	Std. Dev	Std. Error Mean
Pair 1	A1	.7500	40	.95407	.15085
	A2	3.1000	40	.92819	.14676
Pair 2	B1	.6250	40	.77418	.12241
	B2	1.6250	40	1.33373	.21088
Pair 3	C1	1.5500	40	1.33877	.21168
	C2	3.0500	40	1.35779	.21469
Pair 4	D1	1.8000	40	1.60448	.25369
	D2	1.7250	40	.98677	.15602

As presented in Table 7, results show that on average, experimental group scores were 2.35 points higher than the scores for control group (95% CI) for school A (in pair 1). similarly school B mean scores for experimental group was 1.00 points higher than the scores for control group (in pair 2 as in Table 7). Moreover school C mean score for experimental group was 1.5 points higher than the scores for control group (in pair 3). However results show that on average, experimental group scores were 0.075 points lower than the scores for control group (95% for CI). The result for school D may have been affected by the teacher's year of experience and exposure with the use of PBLS since the experimental mean was slightly lower than the control group mean. Nonetheless, proper administration of PBLS is expected to improve performance of learners significantly especially in science-oriented subjects. However, the mean performance of school A was higher than any other school, perhaps attributed by the same factors

Table 8: Results for Paired Sample t-Test for Experimental and Control Samples

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	A1 - A2	-2.35000	.48305	.07638	-2.50449	-2.19551	-30.769	39	.000
Pair 2	B1 - B2	-1.00000	.71611	.11323	-1.22902	-.77098	-8.832	39	.000
Pair 3	C1 - C2	-1.50000	.59914	.09473	-1.69162	-1.30838	-15.834	39	.000
Pair 4	D1 - D2	.07500	.85896	.13581	-.19971	.34971	.552	39	.584

As shown in Table 7 and 8, results show that there was a significant difference in test performance between post-test/ experimental group (M = 3.1, SD = .92819) and pre-test/control group (M = .75, SD = .95407); t(39) = -30.769, p = .000; post-test/ experimental group (M = 1.625, SD = 1.33373) and pre-test/control group (M = .625, SD = .77418); t(39) = -8.832, p = .000; post-test/ experimental group (M = 3.05, SD = 1.35779) and pre-test/control group (M = 1.55, SD = 1.33877); t(39) = -15.834, p = .000; post-test/ experimental group (M = 1.725, SD = .98677) and pre-test/control group (M = 1.7, SD = 1.60448); t(39) = .552, p = .584 for school A,B, C and D respectfully.

The effect size for the difference between the groups was determined using Cohen’s d, giving a value of 0.39, probably pointing to small to slightly medium effect. The results of this research indicate that there is a statistically significant difference between the mean test scores of the experimental group and the control group. Specifically, the experimental group had a higher mean test score than the control group. The study findings illustrate that PBLS strategy effectively improves the test performance of the girls in the topic of ‘Fluid Flow’, with a magnitude of small to medium effect size.

These findings are consistent with the findings reported by Ding (2016); Ulger (2018); Liu and Pásztor (2022) who claimed that the use of PBLS has a greater influence on learner’s ability to gain critical thinking skills in science-oriented subjects. However, Lee et. al., (2016) found contradictions in other researchers’ approach, arguing that there was no statistically significant difference on the use of PBLS on acquisition of learner critical skills. Most of the analyzed studies by Liu and Pásztor and other aforementioned researchers were social sciences and chemistry in higher institutions, but the current study used PBLS in secondary schools especially the girls in the topic of “Fluid Flow “in physics which is one of the STEM subjects. Additionally, the current study used quasi experimental design by randomizing samples (n = 40) while previous studies used descriptive study design to determine studies that fit the inclusion criteria. The results are significant to the government of Kenya, policy makers, schools and other stakeholders on the effect of PBLS on improving learners’ performance especially girls that have consistently performed poor in STEM subjects.

4.3 Problem Solving Abilities of Girls in "Fluid Flow" using PBLS

The study sought to determine the gain in problem solving abilities of girls in "Fluid Flow" when using problem-based learning strategy. The learners were subjected to a test before and after the intervention and which was marked out of 14 marks. Descriptive results are indicated in Table 9.

Table 9: Girls Problem Solving Abilities in Fluid Flow using PBLS

						95% Confidence Interval for Mean			
		N	**Mean**	**Std. Dev**	**Std. Error**	LB	UB	**Min**	**Max**
A1	0-3 Marks	3	1.0000	.00000	.000	1.0000	1.0000	1.00	1.00
	4-6 Marks	11	1.0000	.00000	.000	1.0000	1.0000	1.00	1.00
	7-10 Marks	22	1.1818	.39477	.08417	1.0068	1.3568	1.00	2.00
	11-14 Marks	4	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
	Total	**40**	**1.2000**	**.40510**	**.06405**	**1.0704**	**1.3296**	**1.00**	**2.00**
A2	0-3 Marks	3	1.3333	.57735	.33333	-.1009	2.7676	1.00	2.00
	4-6 Marks	11	2.4545	.52223	.15746	2.1037	2.8054	2.00	3.00
	7-10 Marks	22	3.6818	.47673	.10164	3.4704	3.8932	3.00	4.00
	11-14 Marks	4	4.0000	.00000	.00000	4.0000	4.0000	4.00	4.00
	Total	**40**	**3.2000**	**.91147**	**.14412**	**2.9085**	**3.4915**	**1.00**	**4.00**
B1	0-3 Marks	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	4-6 Marks	11	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	7-10 Marks	22	1.2727	.45584	.09719	1.0706	1.4748	1.00	2.00
	11-14 Marks	4	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
	Total	**40**	**1.2500**	**.43853**	**.06934**	**1.1098**	**1.3902**	**1.00**	**2.00**
B2	0-3 Marks	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00

	4-6 Marks	11	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	7-10 Marks	22	1.3182	.47673	.10164	1.1068	1.5296	1.00	2.00
	11-14 Marks	4	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
	Total	**40**	**1.2750**	**.45220**	**.07150**	**1.1304**	**1.4196**	**1.00**	**2.00**
C1	0-3 Marks	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	4-6 Marks	11	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	7-10 Marks	22	1.5455	.59580	.12703	1.2813	1.8096	1.00	3.00
	11-14 Marks	4	3.0000	.00000	.00000	3.0000	3.0000	3.00	3.00
	Total	**40**	**1.5000**	**.71611**	**.11323**	**1.2710**	**1.7290**	**1.00**	**3.00**
C2	0-3 Marks	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	4-6 Marks	11	1.7273	.46710	.14084	1.4135	2.0411	1.00	2.00
	7-10 Marks	22	2.6818	.56790	.12108	2.4300	2.9336	2.00	4.00
	11-14 Marks	4	4.0000	.00000	.00000	4.0000	4.0000	4.00	4.00
	Total	**40**	**2.4250**	**.90263**	**.14272**	**2.1363**	**2.7137**	**1.00**	**4.00**
D1	0-3 Marks	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	4-6 Marks	11	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	7-10 Marks	22	1.5000	.51177	.10911	1.2731	1.7269	1.00	2.00
	11-14 Marks	4	2.7500	.50000	.25000	1.9544	3.5456	2.00	3.00
	Total	**40**	**1.4500**	**.63851**	**.10096**	**1.2458**	**1.6542**	**1.00**	**3.00**

D2	0-3 Marks	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	4-6 Marks	11	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	7-10 Marks	22	1.2273	.42893	.09145	1.0371	1.4175	1.00	2.00
	11-14 Marks	4	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
	Total	**40**	**1.2250**	**.42290**	**.06687**	**1.0897**	**1.3603**	**1.00**	**2.00**

Results in Table 9 show that the performance of the Girls in school C was slightly better than the other schools before the intervention of PBLS. After the intervention of the method, the performance of the Girls in school A (M = 3.2, SD = .91147) and C (M = 2.425, SD = .90263) was better than school B (M = 1.275, SD = .4522) and D (M = 1.225, SD = .4229) in the same topic. However, school A and C improved significantly after the exposure of PBLS by 62.5% and 38.14% respectively. There seem to be minimal or no improvement by the performance of the Girls in school B and D. It should be noted that these two schools performed poorly before and after the exposure to PBLS. For instance, school A had a minimal improvement of 1.96% while the performance of school D dropped by 18.37% after the intervention. These results point out that even though PBLS has the capacity to improve critical skills among the learners, however, its impact is likely to be affected by other factors such as teacher's pedagogical problems, teacher characteristics, and learner characteristics. This is because PBLS should resonate with the teacher and also the learners' perception of the method is very critical. It should also be understood that learners come from varied backgrounds and that they do not all learn in the same way. Therefore, learners' differences are also likely to affect the use of this teaching strategy. Such differences are likely to impact negatively to science-based process skills (Njoka, et. al, 2019) which are very critical in improving learners' creativity and arousing their perception towards learning.

The current results also indicate that school A and C learners may have had prior exposure to PBLS in the former classes while school B and D learners were being exposed to this strategy for the first time. Therefore, learners' critical skills can be enhanced initially when suitable learning approach is used. In line to these findings, Sholahuddin, et.al. (2020) observed that learners' science-based process skills improved significantly after the use of PBLS among the elementary school learners in Indonesia.

The study further tested the Null Hypothesis (Ho_2): That there is no significant difference in achievement scores in problem solving abilities towards learning of Fluid Flow between girls who are exposed to PBLS and those taught using conventional methods. Analysis of variance was used to compare the variability in the test scores between the different schools and the variability within each school. Results are confirmed in Table 10.

Table 10: ANOVA Results for Problem Solving Abilities in "Fluid Flow" using PBLS

		Sum of Squares	Df	Mean Square	F	Si
A1	Between Groups	3.127	3	1.042	11.467	.000
	Within Groups	3.273	36	.091		
	Total	6.400	39			
A2	Between Groups	24.233	3	8.078	35.608	.000
	Within Groups	8.167	36	.227		
	Total	32.400	39			
B1	Between Groups	3.136	3	1.045	8.625	.000
	Within Groups	4.364	36	.121		
	Total	7.500	39			
B2	Between Groups	3.202	3	1.067	8.051	.000
	Within Groups	4.773	36	.133		
	Total	7.975	39			
C1	Between Groups	12.545	3	4.182	20.195	.000
	Within Groups	7.455	36	.207		
	Total	20.000	39			
C2	Between Groups	22.820	3	7.607	30.582	.000
	Within Groups	8.955	36	.249		
	Total	31.775	39			
D1	Between Groups	9.650	3	3.217	18.528	.000

	Within Groups	6.250	36	.174		
	Total	15.900	39			
D2	Between Groups	3.111	3	1.037	9.664	.000
	Within Groups	3.864	36	.107		
	Total	6.975	39			

Results in Table 10 show that the performance of the girls differed significantly between groups and school since $p < .001$ is less than the selected significance level $\alpha = 0.05$. Therefore, the null hypothesis was rejected in favour of the alternate hypothesis which states that there is significant difference in achievement scores in problem solving abilities towards learning of Fluid Flow between girls who are exposed to PBLS and those taught using conventional methods. It was deduced that the mean performance for control and experimental groups was significantly different

4.4 Effect of PBLS on Girls' Motivation towards "Fluid Flow"

The study sought to establish the effect of problem-based learning strategy on girls' motivation towards "Fluid Flow" as compared to conventional teaching methods. Five aspects of Motivation namely student, teacher, content, teaching method/process and environment were considered on Motivation Towards Physics Scale (MTPS) scale of 1=SD, 2=D, 3=N 4=A 5=SA and results are shown in Table 11.

Table 11: Effect of PBLS on girls' Motivation towards "Fluid Flow"

PBLS Motivation Questions	N	Min	Max	Mean	Std. Dev.
Q2 (Physics lessons are very interesting	160	1.00	5.00	3.8500	1.21934
Q16 (I understand everything that myPhysics teacher teaches	160	1.00	5.00	2.8500	1.21934
Q24 (the teaching methods used by Physics teacher are enjoyable	160	1.00	5.00	3.7875	1.33359
Q26 (I always participate in Physics lessons	160	1.00	5.00	3.7500	1.36902
Q28 (I cooperate with other students during Physics experiments	160	1.00	5.00	3.8500	1.39270
Valid N (listwise)	**160**				

As shown in Table 11, results showed that all students were motivated with the Physics lessons and they attested that the lessons were interesting (M=3.85; SD=1.21934). The girls enjoyed the lessons, and understood physics problems and calculations and abstract terms with ease through exposure to PBLS. However, the students had varied opinion about everything taught by their physics teachers as this scored slightly lower (M=2.85; SD=1.21934). Therefore, the perception of learning physics differed significantly with the teacher handling these lessons. Perhaps some students find the lessons challenging due to the teacher characteristics which ultimately affected their performance in physics.

Furthermore, majority of the students agreed that the teaching methods used by the Physics teacher were enjoyable (M=3.7875; SD=1.33359). The use of PBLS incorporated diverse methods of group discussions, demonstration and use of experiments/practical work which enhanced student's curiosity. Learners were able to participate in the lessons by asking relevant questions and they got involved in the tasks assigned. The analysis of observation schedules showed that variation of the teaching methods made lessons well organized, and learners were able to connect the classroom environment with real life situations.

Moreover, most learners always participated in Physics lessons (M=3.75; SD=1.36902), hence, physics content is practical in nature and the use of PBLS made the learners more attentive to physics lessons unlike theory lessons. Consequently, majority of the learners were able to cooperate with other students during Physics experiments (M=3.55; SD=1.39270) as a result of the effect of PBLS. This also implied that the learning environment motivated learners when undertaking such lessons. Teachers should therefore ensure that physics lessons resonate well with the environment in order to attain the overall objectives of the lessons. The current results are similar to those of Kanyesigye, Uwamahoro & Kemeza (2022), who investigated the impact of problem-based learning strategy on learners' attitudes in learning physics among 419 grade 12 learners undertaking physics in both public and private secondary schools in Uganda. They found that the experimental cohort acquired more positive attitude as compared to the control cohort.

The authors resolved that PBLS was effective in the instruction of physics as a subject as compared to the conventional teaching methods with approximately 20% gain in attitudes. It was evident that application of PBLS in relaying abstract terms and concepts in STEM subjects in secondary school would enhance skill development among the learners.

The study further analyzed students Motivation towards the topic ‘Fluid Flow’ using analysis of variance to test the hypothesis which stated that;(Ho_3): There is no significant difference in the level of motivation towards Fluid Flow, a topic in physics, among girls who are exposed to PBLS and those taught using conventional methods. The analysis of variance was used to compare the variability in test scores between the different schools and the variability within each school. ANOVA test used the sum of squares method and statistically allowed the investigator to test the hypothesis to find the existence of statistical variance between means of groups. This was critical to determine the variability of PBLS in comparison to the conventional method. Findings are shown in Table 12:

Table 12: Results of ANOVA on Effect of PBLS on Girls' Motivation towards "Fluid Flow"

		Sum of Squares	Df	Mean Square	F	Sig.
Q2	Between Groups	218.029	4	54.507	459.886	.000
	Within Groups	18.371	155	.119		
	Total	236.400	159			
Q16	Between Groups	218.120	4	54.530	462.375	.000
	Within Groups	18.280	155	.118		
	Total	236.400	159			
Q24	Between Groups	270.180	4	67.545	831.272	.000
	Within Groups	12.595	155	.081		
	Total	282.775	159			
Q26	Between Groups	280.334	4	70.084	614.907	.000
	Within Groups	17.666	155	.114		
	Total	298.000	159			
Q28	Between Groups	281.575	4	70.394	406.743	.000
	Within Groups	26.825	155	.173		
	Total	308.400	159			

The ANOVA test was used to examine causes of variability in data observation in terms of variability between groups and variation within groups and variance in total observations. The choice of ANOVA test to this hypothesis was much preferred than other tests like multiple t-tests because ANOVA minimizes the Type 1 error (error due to chance) unlike the t-test statistic (Gray, Grove & Sutherland, 2017). The p -value in the test gives useful direction on whether we can reject or retain the null hypothesis (Ho) in the test. A significant level of $\alpha = 0.05$ is used to validate the claim of the hypothesis in satisfying ANOVA assumptions. However, according to (Polit & Beck, 2018), variability within groups is compared to variability between groups using the F-ratio (F=statistic). If the observations are true with the null hypothesis, then no statistical difference is shown between the groups, whereby F-statistic is closer to 1. Moreover, a larger value illustrates that the difference between groups with independent construct(s) is genuine (Mishra, Hsham, Manjunatha, Ray, Homa, & Pawanya, 2023) A significant p-value of < 0.05 implies that the means of the groups vary from one another by large amounts for the difference to be statistically significant.

As shown in Table 12, the effect of PBLS on girls' motivation towards 'Fluid Flow' for the five questions had significant positive regression weights, showing teachers use of PBLS improved girls' motivation in learning physics as a science subject.

A one-way ANOVA as presented in Table 12 indicate that the significance value was 0.000 (i.e., $p = .001$) for all the questions, which is below the set alpha value (α=0.05). Therefore, there is a statistically significant difference in the mean performance of physics in the topic 'Fluid Flow' between the different groups of students (control and experiment). The F ratios were then calculated as variation between sample means (control and experiment)/variation within the samples (control and experiment). The F ratios obtained, as seen in Table 12 were bigger than the F-critical value found in a table indicating that there is more variability between the groups (cause by independent construct) than there is within each group (error term). The ANOVA F statistic tests (Q2 =459.886; Q16 =462.375; Q24 =831.272; Q26 =614.907 and Q28 =406.743), p=.000

respectively in the model as a whole was significant, since the critical F=value calculated was higher than the critical table value of 2.422 ($F_{calculated} > F_{table\ value}$). The larger the F-value in an ANOVA, means the higher the variation between sample means relative to the variation within samples. Since the F-statistic was greater than the critical value (2.422), the study rejects the null hypothesis in favor of the alternative hypothesis and deduce that there is significant difference in the level of motivation towards Fluid Flow, a topic in physics between girls who are exposed to PBLS and those taught using conventional methods.

Teachers are to use teaching methods such as PBLS to enhance learners' attitudes (Mbonynyivuze, Yadav & Amadalo, 2021); (Kanyesigye & Kemeza, 2021). This observation was seen in public secondary schools in Uganda among students taking physics and compares with the current study undertaken among public girls' secondary schools in Bungoma County, Kenya.

A regression analysis was then performed and yielded the results as in Table 13 below

Table 13:Model Summary for Effect of PBLS on Girls' Motivation towards "Fluid Flow

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.983[a]	.967	.966	.25230

a. Predictors: (Constant), Q28, Q16, Q2, Q24, Q26

In determining the variable contribution of learners' motivation towards Fluid Flow in Physics, findings in Table 13 demonstrate the model summary statistics and the results reveal that the model could predict 96.6% of the performance of physics when exposed to PBLS. The R-squared value was 0.983 showing the correlation coefficient between the groups and test score performance was highly significant.

Furthermore, the model shows the outcome size of the analysis which was a huge magnitude (Larson-Hall, 2010), its square value was .967 and its adjusted square was .966. This signifies that 96.6% of the variation in the test score performance at the study schools could be explained by taking learner characteristics and their difference, teacher characteristics and their tactical use of PBLS, learning environment, content and method of delivery into account, perhaps are motivating factors that determine students' performance in general.

In line to Larson-Hall (2010) and with reference to the quantity of the adjusted R square, it can be inferred that student motivation could justify 96.6% variance of the performance of physics to a greater extent. This motivation is usually context specific and relies strongly on the classroom situation. Therefore, girls need to believe that they are capable of performing a task, that they have some control over the task and that the task is achievable. Many teachers point out that low achievement in Physics is as a result of negative attitudes by the learners as well as omitted linkage between primary and secondary science syllabus (Mohan, 1997). Results in this study indicate that learners' motivation significantly influence performance of physics and science related subjects. Song and Keller (2001) argue that motivational belief can influence the process of learning and conceptual changes.

4.5 Girls Ability to Illustrate Bernoulli's Effects in nature using PBLS

The study sought to determine whether girls are able to describe experiments to illustrate Bernoulli's effects in nature when using problem-based learning strategy. The girls were tasked to describe the experiment before and after the exposure of the PBLS in four schools. Each group had 40 students and the control group was designated as 1 while the experimental group was designated as 2. Descriptive results are as shown in Table 14.

Table 14: Descriptive Results for Girls' Ability to Illustrate Bernoulli's

School	1='0-5Mks'		2='6-11Mks'		3='12-17Mks'		4=18-23Mks						
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**N**	**Min**	**Max**	**Mean**	**SD**
A1	28	70.0	10	25.0	02	5.0	00	0.0	40	1.0	3.0	1.3500	0.57957
A2	00	0.0	09	22.5	28	70.0	03	7.5	40	2.0	4.0	2.8500	0.53349
B1	32	80.0	08	20.0	00	0.0	00	0.0	40	1.0	2.0	1.2000	0.40510
B2	28	70.0	12	30.0	00	0.0	00	0.0	40	1.0	2.0	1.3000	0.46410
C1	34	85.0	06	15.0	00	0.0	00	0.0	40	1.0	2.0	1.1500	0.36162
C2	14	35.0	18	45.00	04	10.0	04	10.0	40	1.0	4.0	1.9500	0.93233
D1	21	52.5	19	47.5	00	0.0	00	0.0	40	1.0	2.0	1.4750	0.50574
D2	25	62.5	14	35.0	01	2.5	00	0.0	40	1.0	3.0	1.4000	0.54538
Total	**182**	**56.9**	**96**	**30.0**	**35**	**10.9**	**07**	**2.2**	**320**	**1.0**	**4.0**	**1.5844**	**0.77119**
CONT	115	71.9	43	26.9	02	1.2	00	0.0	160	1.00	3.00	1.2937	0.48366
EXP	67	41.9	53	33.1	33	20.6	07	4.4	160	1.00	4.00	1.8750	0.88843

Analysis of the girls' ability to illustrate Bernoulli's effectsin Table 14 shows that majority, 115 (71.9%) of the students scored between 0-5marks; 43 (26.9%) scored between 6-11 marks and 2 (1.2%) scored between 12-14 marks which exhibited M=1.2937; SD=0.48366. After the exposure to PBLS, the students significantly demonstrated the ability to illustrate the Bernoulli's effects whereby 67 (41.9%) of the students scored between 1-5 marks; 53 (33.1%) scored between 6-11 marks, 33 (20.6%) scored between 12-17 marks while7 (4.4%) scored between 18-22 marks, out of a total of 25 marks, giving a M=1.8750; SD=0.88843. This demonstrates a 45.0% improvement of the overall performance of the girls in illustrating the Bernoulli's effects after the exposure to PBLS. However, the girls from school A did better than all the other schools with a mean increase of 111.11% after the exposure of the method. Similarly, school C was the second best with a mean increase of 69.57% after the exposure of the method. School B did not do well with a slight mean increase of 8.33% but the illustration of the girls from school D on the Bernoulli's effects was negative with mean of -5.36% after the exposure to the PBLS. Generally, the ability of the girls to illustrate the Bernoulli's effects before and after the exposure of the PBLS in the four girls' schools is reflected in their percentage performance in fig 3 and 4.

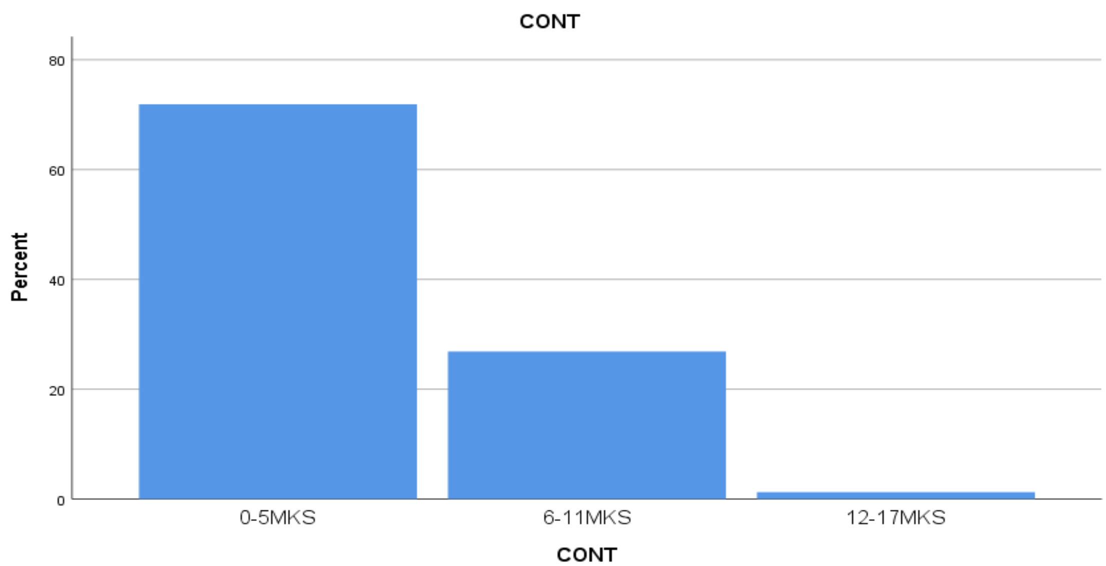

Figure 3: Control Group's Ability to Illustrate Bernoulli's Effects

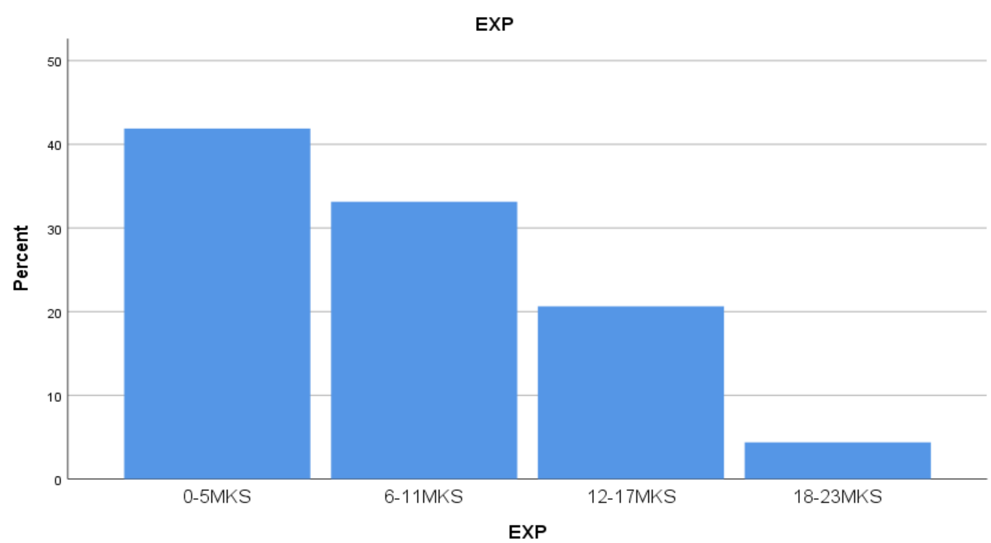

Figure 4: Experimental Group's Ability to Illustrate Bernoulli's Effects

The study further tested the Null Hypothesis (Ho_4): That there is no significant difference in achievement scores in ability of girls exposed to PBLS to describe experiments that illustrate Bernoulli's effect in nature and those who are taught using conventional methods. Analysis of variance was used to compare the variability in test scores between the different schools and the variability within each school. ANOVA test applies the use of the sum of squares method and statistically allows a researcher to test the hypothesis to establish the existence of statistical variance between means of groups (Connelly, 2021) Results are confirmed in Table 15

Table 15: ANOVA Results for Girls' Ability to Illustrate Bernoulli's Effects

ANOVA						
Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	26.874	8	3.359	33.319	.000[b]
	Residual	3.126	31	.101		
	Total	30.000	39			

a. Dependent Variable: E
b. Predictors: (Constant), D2, A2, C1, D1, B2, B1, C2, A1

As seen in Table 15, girls' ability to illustrate Bernoulli's effects had significant positive regression weights, indicating teachers use of PBLS properly was expected to have effective acquisition of critical skills among the students, after regulating other constructs in the model. Therefore, ANOVA F statistic tests (33.319) in the model as a whole was significant. It can be presumed that there was a statistically significant difference between groups as determined by one-way ANOVA (F (8,31) = 33.319, p = .000). Therefore, ANOVA F-statistic test (33.319) in the model as a whole was significant as the critical F (value calculated was higher than the critical table value of 2.255). These results show that there was statistically significant difference between variables of girls' ability to illustrate Bernoulli's Effects as determined by one-way ANOVA (F (8.31) =33.319, p=.000)

Since the F-statistics was greater than the critical value (33.319>2.255) the study rejects the null hypothesis in favor of the alternative hypothesis and deduce and concludes that there is significant difference in the ability of girls exposed to PBLS to describe experiments that illustrate Bernnoulli's effect in nature than those who are taught using conventional methods. In other terms, the PBLS overall predict the dependent variable better. This is why teachers with robust experience in the use of PBLS are expected to have higher mean scores in the performance of their students especially in science-oriented subjects.

The study also investigated the regression model summary and findings are shown in Table 16

Table 16: Model Summary for Girls' Ability to Illustrate Bernoulli's Effects

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.946[a]	.896	.869	.31753	.896	33.319	8	31	.000	1.022

a. Predictors: (Constant), D2, A2, C1, D1, B2, B1, C2, A1

b. Dependent Variable: E

In determining variable contribution of the PBLS on ability of the girls to illustrate Bernoulli's effects, findings in Table 16 demonstrate the model summary statistics and results reveal that the model could predict 86.9% on demonstration of the experiment. The R value was 0.946 which shows the correlation coefficient between PBLS and illustration of Bernoulli's effects.

The R^2=0.896 indicates that 89.6% of the association in dependent construct can simply be attributed to the effect of independent constructs. However, only 10.4% cannot be explained. In an adjusted R^2=0.869 roughly points out the model in general. The difference in the two gives 0.896-0.869=0.027 which implies that when the model is ultimately extracted from targeted population other than the sampled units, it may result in approximately 2.7% variance of the result. The 2.7% variance is also less than the proposed errors of 5% in all the reported answers.

Furthermore, the model shows the outcome size of the analysis which was a slight magnitude (Larson-Hall, 2010) as the square value was 0.896 and its adjusted square was 0.869. This signifies that 86.9% of the variation on the illustration of Bernoulli's effects could be explained by taking PBLS into account. The results of this study also indicate that there is a statistically significant difference between pre and post exposure of PBLS and the ability of the girls to illustrate Bernoulli's effects. The overall regression was statistically significant (R^2 = .896; F (8, 31) = 33.319; p=.000.

ANOVA F-statistic test 33.319) in the model as a whole was significant as the critical F-value calculated was higher than the critical table value of 2.255. These results show there was statistically significant difference between variables of ability of girls to illustrate Bernoulli's Effects as determined by one-way ANOVA (F (8.31) =33.319, P=.000

Since the F-statistics was greater than the critical value, the study rejects the null hypothesis and deduce that and conclude that there is significant difference in the ability of girls exposed to PBLS to describe experiments that illustrate Bernoulli's effects in nature than those who are taught using conventional methods

The effect of the auto correlation between the groups was positive, with a Durbin-Watson of 1.022 (0-2=positive; 2-4=negative) implying that the use of PBLS improves learner's critical thinking skills. The students can easily remember the experiments because they are used to introduce new concepts/ideas or rather clarify confusing aspects of the topic. Therefore, the use of class experiments in teaching and learning enhanced critical thinking skills among students. Students find certain concepts or theories difficult to comprehend when taught in normal theory or lecture.

The current results are similar to the findings of Tambunan (2019) in Indonesia. He found that learning through problem solving strategy was statistically significant than the scientific approach to learners' mathematical abilities in communication, creativity, problem solving and mathematical reasoning. Zhao, et. al., (2020) noted that learners who are involved in experiments significantly perform better in tests whereas researchers such as Saleh, et. al., (2022) suggest that learners must be guided in experiments to provide them with scaffolds and heuristics. This essay examines evidence of learners ability to demonstrate experiments.

Moreover, a similar randomized study conducted by Anazor & Achufusi-Aka (2023) found that learners exposed to PBL Approach performed better than those exposed to lecture method. The authors examined the effect of problem-based learning approach on learners' academic performance among 127 sampled physics learners in secondary schools in Nigeria. They recommended that school administrators encourage teachers to attend seminars and workshops on enhancing use of PBL in science-oriented subjects. Further, the study analysed the qualitative data and findings were as follows from the observation guides:

During the observation in the administration of the method, according to the teachers, the PBLS was important for learners to build critical skills and perhaps the capacity to use the skills in problem solving issues. Most of them pointed out that developing such method required determined and experienced teacher and solid advocacy by the school. So, with frequent use of this method, learners would have mastery of the processes and procedures carrying out experiments and connect to the real-life situations. However, the structure of the session, teacher's presentation of the method and students' involvement was non satisfactory and therefore, the method may not have been applied properly. The method required careful planning and involvement in research skills by both the teachers and the students. In addition, inadequate resources for the use of PBLS have been the major challenge of teaching STEM subjects in secondary schools. Most of the students had never been exposed to this method and found it very interactive for the first time. Therefore, continuous exposure of the students will improve the performance of the students not only in the topic of 'fluid flow' but in other topics of physics in general.

4.6 Summary

This chapter has looked at data presentation, analysis, interpretation and discussion of the study findings. Raw data was analyzed using means, standard deviation and percentages. Coded data was then subjected to descriptive statistics which summarized data characteristics. Inferential statistics helped the researcher draw predictions based on the hypotheses that had been created. Inferential statistics were used because they were the most useful tools to be applied to help the researcher make educated predictions about how sets of data that had been obtained would scale when applied to a large population of subjects. The inferential statistics also helped set a bench-mark for hypothesis testing

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter focuses on the summary of the major findings of the research both descriptive and inferential. This is followed by a presentation of the conclusions inferred from the results. The recommendations are suggested and ultimately areas for further research.

5.2 Summary of Findings

The major results were summarized in this section as shown in various subsections highlighted.

5.2.1 Ability to Derive the "Equation of Continuity" in the topic "Fluid Flow" when using PBLS

The study purposed to investigate whether girls are able to derive the "equation of continuity" in the topic "Fluid Flow" when using Problem Based Learning Strategy. Results show that there was a significant difference in test performance between post-test/ experimental group and pre-test /control group indicating that PBLS effectively improved performance of the girls as it had greater influence on critical thinking skills and ability to demonstrate problem solving skills. The effect size for the difference between the groups was determined using Cohen's d, giving a value of 0.39, probably pointing to small to slightly medium effect.

5.2.2 Problem Solving Abilities of Girls in the Topic of “Fluid Flow” when using PBLS

The study sought to determine the gain in problem solving abilities of girls in “Fluid Flow” when using problem-based learning strategy. Results showed that the performance of the girls differed significantly between groups and school since $p < .001$ is less than the selected significance level $\alpha = 0.05$. Therefore, the null hypothesis was rejected in favour of the alternate hypothesis which states that there is significant difference in problem solving abilities towards learning the topic of Fluid Flow between girls who were exposed to PBLS and those taught using conventional methods. It was deduced that the mean performance for control and experimental group was significantly different.

5.2.3 Effect of PBLS on Girls’ Motivation towards “Fluid Flow”

The study sought to establish the effect of problem-based learning strategy on girls’ motivation towards “Fluid Flow” as compared to conventional teaching methods. Five aspects of Motivation namely student, teacher, content, teaching method/process and environment were considered on Motivation Towards Physics (MTPS) scale of 1=SD, 2=D, 3=N 4=A 5=SD and results showed that all learners were motivated with the physics lessons and they attested that the lessons were interesting. The girls enjoyed the lessons, they understood physics problems, calculations and abstract terms with ease through exposure to PBLS.

However, the perception of learning physics differed significantly with the teacher handling the lessons, perhaps students found the lessons challenging due to teachers ‘characteristics which ultimately affected their performance in physics. The use of PBLS incorporated diverse approaches, such as, group discussion, practical work, self-directed learning, collaboration and enhanced communication among learners which created curiosity, as learners were able to connect the classroom environment to real life situations. Thus, the learning environment motivated the learners. Teachers should ensure that physics lessons resonate well with environment in order to achieve overall objectives of the lesson. The effect of PBLS had significant positive regression weights showing that teachers use of PBLS improved girls’ motivation in learning physics as a science subject. Thus, there was significant difference in the mean performance in physics between the experimental and control groups as p=.001 for all questions was below the set α= .05.

Calculated F-ratios were bigger than the F-critical value in table indicating more variability between groups (cause by independent construct) than variability within each group (error term). Thus, the study rejected the null hypothesis for the alternative hypothesis which deduced that there is significant difference in the level of motivation towards Fluid Flow between girls who are exposed to PBLS and those who are taught using conventional methods. Teachers were to use PBLS for enhanced learner attitude change, even as suggested by Kanyesigye and Kemeza (2021), and Mbonyinyivuze, et. Al (2021). Therefore, as the results in the study indicate, motivation significantly influences performance in physics in the topic ‘Fluid Flow’ between the different groups of students (control and experiment) as determined by a one-way ANOVA.

5.2.4 Girls Ability to Illustrate Bernoulli's Effects

The study sought to determine whether girls are able to describe experiments to illustrate Bernoulli's effects in nature when using problem-based learning strategy. The girls were tasked to describe the experiment before and after the exposure of the PBLS**.** Results indicate that girls' ability to illustrate Bernoulli's effects had significant positive regression weights, indicating a statistically significant difference between groups as determined by one-way ANOVA (F (8,31)**,** p = .000

ANOVA F-statistic test 33.319) in the model as a whole was significant as the critical F-value calculated was higher than the critical table value of 2.255. Since the F-statistics was greater than the critical value, the study rejects the null hypothesis and deduce that and conclude that there is significant difference in the ability of girls exposed to PBLS to describe experiments that illustrate Bernoullis effects in nature than those who are taught using conventional methods

5.3 Summary of the main findings

Learners perform significantly better and have good retention of what is learnt if appropriate teaching/learning approaches are adopted. In this study, problem solving abilities improve with use of PBLS, ability of the girls to derive the "Equation of Continuity" in the topic "Fluid Flow" and the ability to describe experiments in nature also improve with use of PBLS. Thus, when learners use PBLS the improvement of these abilities are noted and will lead to improved achievement in physics as one of the main problems that neccesated this study.

The findings have also shown that use of PBLS improved the girls' motivation towards the topic fluid flow and therefore improved positive motivation towards physics as a subject. This positive motivation in physics would in the long-run lead to increased enrolment in physics at form three level.

5.4 Conclusions

Arising from the study findings, the following conclusion can be made:

a) Use of PBLS can lead to learners improved ability in deriving the equation of continuity, improved problem- solving abilities in the topic fluid flow and improved ability to describe experiments which demonstrate Bernoulli's principle in nature, which will lead to improved performance/achievement in physics.
b) Use of PBLS makes the girls to be positively motivated towards physics, hence leading to improved enrolment.

5.5 Recommendations

Based on the results of this study, PBLS led to enhanced ability to derive continuity equation in fluid flow, acquisition of problem-solving abilities, achievement and motivation in physics in subcounty girls' schools in Bungoma county, Kenya. It was therefore recommended that:

a) Physics teachers to incorporate use of PBLS in the teaching and learning of physics as a way of enhancing enrolment at form three and achievement in the subject in sub-county girls' schools and in all schools.

b) PBL approach be adopted as a teaching strategy within the regular in-service and pre-service courses for teachers of STEM.
c) The heads of schools in liaison with the Boards of Management to invest in teacher capacity building programs through mounting workshops and seminars that encourage use of PBL strategy especially for STEM,

5.6 Suggestion for Further Studies

Based on the findings of the study, the following areas have been identified for further research;

a) Studies involving other classes and gender should be carried out to determine effect of PBLS across different classes in secondary schools to give insight on the benefits of this strategy on students at different level of learning
b) Studies to be done to assess the facilities available in Kenyan secondary schools for proper implementation of PBLS
c) Studies should be done to determine the views of physics teachers on use of PBLS

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APPENDICES

Appendix I: Introduction letter to schools

To the Principal,

I am a research student from the school of Education in UoE taking Doctor of Philosophy degree in science education (Physics Education). I intend to investigate; *Effect of Problem Based Learning Strategy on achievement in Physics in Sub County girls' Secondary schools in Bungoma County - Kenya* and therefore requesting that you allow me to conduct the research in your school. This exercise will involve your teachers of physics as well as your form 2 students. I intend to be in your school for at least 5 weeks.

During this period, I will observe at least one physics lesson, I will also subject the learners to 2 examinations (that will be done before the start of the research and after the research. All the information will be treated with utmost confidentiality and will only be accessed by the researcher, and her supervisors. The research findings will be utilized to inform physics education development policies anonymously. Copies of the findings can always be made available on request. The participants will be informed about their right to withdraw from the study and the researcher will be available to clarify any issues that may arise during this time.

Gladys Mang'eni

Research Student

University of Eldoret

Appendix II: physics achievement test (pat)

MODULE FOR ADMINISTRATION OF THE PROBLEM BASED LEARNING STRATEGY IN PHYSICS PRACTICAL TEST

The module proceeded as follows:

Step one: Before the student arrived, the teacher set out the material and equipment following an agreed standard layout on the table. The teacher greeted the students and explained in general terms that a practical investigation was to follow. The tester used the students' first name in conversation. But this was not to be recorded and the tester was not to know the student's identity. Once seated, the students were introduced to the problem and the equipment. The teacher then handed the students the question paper. Students were helped in reading this paper where necessary. The tester then invited each student to ask any question to clarify the task before being told to go ahead. Each student was asked to state in his or her words what the problem was all about.

Step two: The test then begun. The tester watched what was done as the student carried out the investigations and filled the effect list as the experiment proceeded. The tester then recorded each action undertaken by the student as it took place and decided when one trial was completed and another one started. Occasionally, if students asked for advice or approval during the investigation process, then they were to be told, "You have been told what to do/" the tester only intervened when the learner's safety was threatened.

Step three: This is when students had completed the task. The students writing the results of their investigation/test on their paper, or finishing their written work was accounted of what they had done would signify this. The tester then marked students work and checked all questions by the check list. The final questions were put to the students along lines, “would you do the same experiment/questions in the same way if you could begin again?” The response to this opportunity to reflect critically on what has been done was noted. After completing one investigation, the student would be required to tackle the second problem. Testing the student on one problem or experiment took at most 20 minutes.

QUESTION ONE: PRE-TEST

TIME: 1HR, 30 MINS

Instructions to the candidates

Answer all the questions in the spaces provided

All your working must be clearly shown.

Use well drawn diagrams for your illustrations if necessary.

1. (a) Derive the equation of continuity (5marks)

(b) In deriving the equation in (a) above, state any three assumptions made (3 marks)

2. A lawn sprinkler has 40 holes, each of cross-section area 2.0×10^{-2} cm^2. It is connected to a hose-pipe of cross-section area 1.6 cm^2. If the speed of the water in the hose-pipe is 1.2 ms-1, calculate the:

a) The flow rate in the hose-pipe (2 marks)

b) The speed at which water emerges from the holes (3marks)

3The velocity of glycerin in a 5cm internal diameter pipe is 1.00m/s. find the velocity in a 3cm internal diameter pipe that connects with it, both pipes flowing full. (3marks)

4. A) students held a piece of paper in both hands in front of her mouth. The paper hang downwards

She then blew air over and parallel to it

i) what was her observation? 1mk

ii) explain the observation in (a) above 2mk

b. she then held two foolscaps close and parallel to each other and gently blew air between them, what observations did she make?

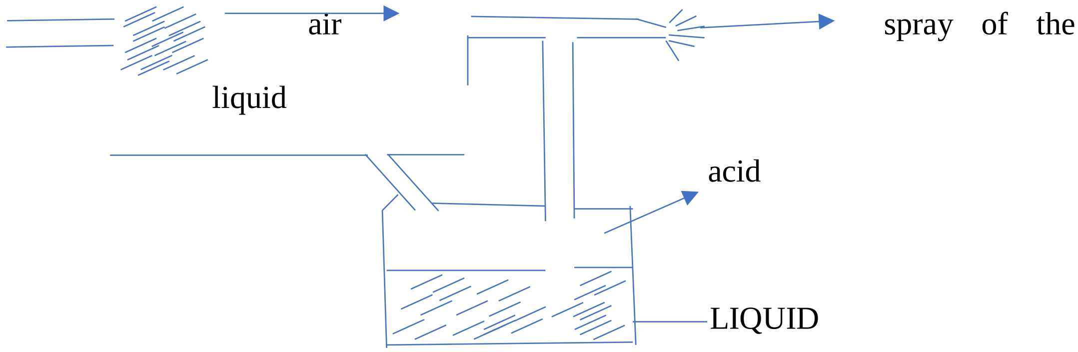
c. Give explanation to this observation 2mks

A small plastic ball was made from Styrofoam and placed on a table. Air was blown hard through the narrow part of the funnel downwards towards the plastic ball

State what was observed

Explain this observation using a diagrammatic illustration

5The diagram below shows a spray gun



Explain how it works 5mks

QUESTION TWO: POST-TEST

TIME: 1HR, 30MINS

PORM TWO

TOPIC' FLUID FLOW

QUESTION ONE

ACTIVITY ONE

1/ In this activity, you are to derive the equation of continuity in the topic Fluid Flow. The assumptions that will be made is that the fluid is flowing through a section of a pipe that has a varied cross section area along its length, and that the fluid is non-viscous, incompressible and the flow is steady. You may find the following resources useful

'Refer to this site; https://www.youtubecom/watch=J5JG6F301Js and Visit the link: https://byjus.com and watch the video carefully for the derivation of continuity equation

using a smartphone or laptop' and Physics KLB 4^{th} Edition Form 2

Question 1

Derive equation of continuity (use an appropriate diagrammatic illustration) (5 marks)

Question 2

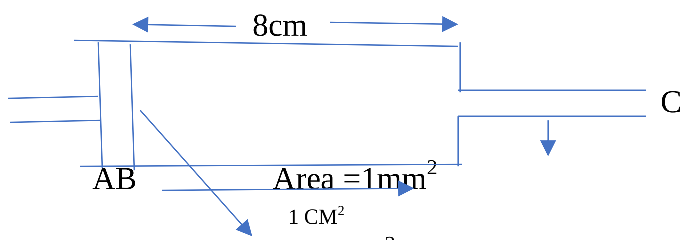
A lawn sprinkler has 40 holes, each of cross-section area 2.0×10^{-2} cm^2. It is connected to a hose – pipe of cross – section area $1.6cm^2$. if the speed of the water in the hose pipe is $1.2ms^{-2}$, Calculate the;

a. The flow rate in the hose pipe 2mks

b) The speed at which water emerges from the holes. 3mks

Question 3

In the figure below, the tube ABC is filled with a liquid. The piston moves from A to B in 1 second.



Calculate; AREA= 1CM^2

a. The volume of the liquid in part AB

b) velocity of the liquid between A and B.

c) The velocity of the liquid through B and C.

Question 4

The velocity of glycerin in a 5cm internal diameter pipe is 1.00m/s. find the velocity in a 3cm internal diameter pipe that connects with it, both pipes flowing full. (2 marks)

Question 5

ACTIVITY III

You are provided with the following;

Foolscaps, 2 ball pen casings, water in measuring cylinder, and internet source

a. Predict what would happen if air is blown over the surface of piece of paper / foolscap.

b. Hold a piece of paper in front of your mouth then blow air over and parallel to it. What do you observe? Explain your observations (3 marks)

c). Predict what would be observed when air is blown between two foolscaps held parallel to each other. (1 mark)

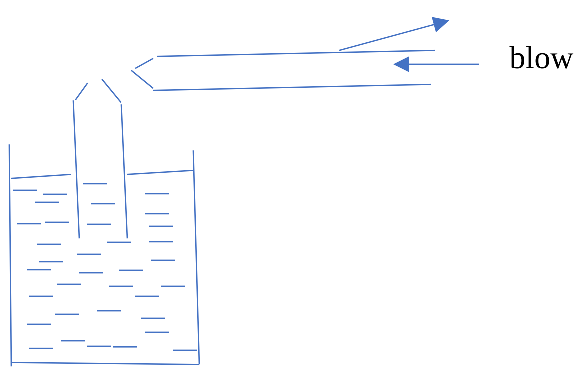
d) Hold two foolscaps close and parallel to each other and gently blown air between them. (Alternatively, fold foolscap at the middle and blow air in between.) What observations have you made? Explain your observations (3 marks)

c. Repeat step (d) when air is strongly blown between the sheets of paper and record your observations (2 marks)

ACTIVITY IV

a) Place two ballpoint casings perpendicular to one another with the vertical one dipped in water contained in a beaker (see the diagram shown below). Blow air through the horizontal ballpoint casing. Explain your observation (3 marks)

NB The blowing should be hard.

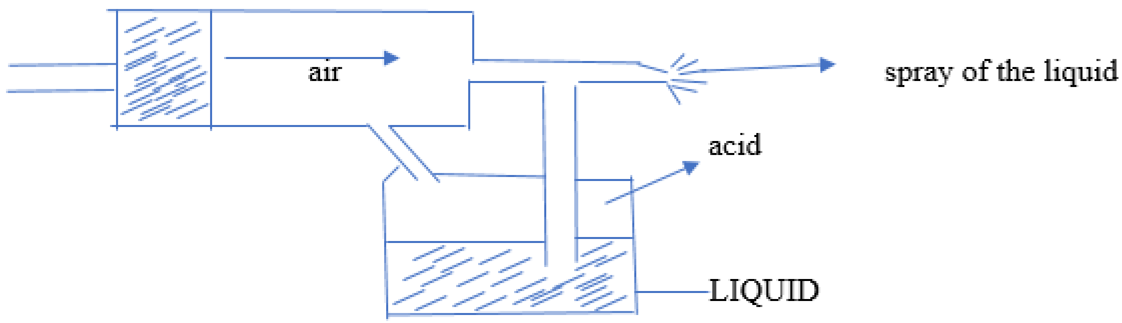


What do you observe? (2marks)

Explain your observation (3 marks)

Application

The diagram below shows a spray gun.



Explain how it works. (5marks)

END

Appendix III: Motivation questionnaire

INSTRUCTIONS

The Motivation Questionnaire contains a large number of statements. It not A TEST. The information obtained will be used for research, which aims at improving the learning of Physics in schools. Only the researcher will have access to the information about your responses.

THERE ARE NO RIGHT OR WRONG ANSWERS. What is required is your personal feelings OR opinions ON EACH STATEMENT OR QUESTION. Please answer ALL questions as quickly as you can.

NO NAMES ARE REQUIRED

Use a pencil to fill the Questionnaire. If you change your opinion on any statement or Question, clearly erase the response before making the necessary adjustment.

SECTION A

SEX MALE ☐ FEMALE ☐

AGE (Years)________________________________

For the following section, please indicate the extent to which you agree with the statement in each of the following questions. Indicate whether you **Strongly Agree (SA), Agree (A), Uncertain(U), Disagree (D) or Strongly Disagree (SD)** by **CIRCLING** the letters that best describe your level of agreement

	SA	A	SD	D	U
1. I find Physics quite easy to understand	SA	A	SD	D	U
2. Physics lessons are very interesting	SA	A	SD	D	U
3. Learning Physics is fun	SA	A	SD	D	U
4. Learning Physics is enjoyable	SA	A	SD	D	U
5. Physics lessons are pleasing	SA	A	SD	D	U
6. I find Physics terms very abstract	SA	A	SD	D	U
7. I perform well in Physics	SA	A	SD	D	U
8. Calculations in Physics are very easy	SA	A	SD	D	U
9. I like discussing Physics problems with other students	SA	A	SD	D	U
10. Physics is my favorite subject	SA	A	SD	D	U
11. I am always eager to learn Physics	SA	A	SD	D	U
12. Learning Physics is exciting	SA	A	SD	D	U
13. I always do Physics assignment	SA	A	SD	D	U
14. I easily remember what I learn in Physics	SA	A	SD	D	U
15. I always try to answer questions during Physics classes	SA	A	SD	D	U

16. I understand everything that my Physics teacher teaches	SA	A	SD	D	U
17. What I learn in Physics is important	SA	A	SD	D	U
18. I always try to get good marks in Physics	SA	A	SD	D	U
19. Physics lessons are challenging	SA	A	SD	D	U
20. learning Physics is stimulating	SA	A	SD	D	U
21. I have self-confidence regarding Physics studies	SA	A	SD	D	U
22. Physics lessons are well organized	SA	A	SD	D	U
23. Learning Physics is rewarding	SA	A	SD	D	U
24. The teaching methods used by my Physics teacher enjoyable	SA	A	SD	D	U
25. I apply Physics knowledge in other subjects	SA	A	SD	D	U
26. I always participate in Physics lessons	SA	A	SD	D	U
27. I am always attentive in Physics lessons	SA	A	SD	D	U
28. I cooperate with other students during Physics experiments	SA	A	SD	D	U

29. I would like to be a Physics teacher	SA	A	SD	D	U
30. I would like to pursue a course related to Physics	SA	A	SD	D	U

Appendix IV: Physics observation schedule

PART A

To be used in observing activities that goes on within the physics classroom.

General information

County…………………. Sub-County………………………...

School………………………. Class…………………………...

Subject……………………. Topic taught……………………….

No of students in class………………………

Teacher (a) Male………………………...

(b) Female……………………...

c)Age; i) 20-30 ii)31-40 iii)41 and above

d) Length of stay since posting………………

Activity	Comment
(1) INSTRUCTIONAL METHOD **A. Lesson Introduction** What method is used to introduce the lesson? • Lecture • Review of previous lesson • Demonstration of some activity	

• Discussion • Teacher checks students work • Students carry out exercises • Others	
B. Lesson Development How is the lesson developed? • Lecture • Discussions • Class practical activity • Class demonstration • Group work • Class presentation • Watch a video clip • Exercises (at what level is this given and how is it administered? -does the teacher mark the exercises? Or does she/he ask students to do it?) • Others	
C. Lesson Conclusion How is the Lesson concluded?	

• Teacher asks questions on content • Exercises are given to be marked later/ corrected at the end of the lesson • Students ask questions/ give their views • Summary done on chalkboard and students copy • Students asked to summarize main points individually or in groups. Are students given individual attention? • Does the teacher consolidate the key points? • Indicate any other method observed in class not included above	
(II) STUDENTS' PARTICIPATION Who initiates the interaction in class and what form does this take? • Teacher asks individual students questions • Student asks questions • Are students meaningfully engaged in learning activities?	

• Were materials, demonstrations appropriate for the purpose? • Did the teacher actively solicit students' ideas on content being taught? • Did the teacher relate the students' ideas to the content being taught? • Did the teacher correct students' misconception? • How does the teacher respond/ react when students ask questions? – Are students' attempt to ask questions acknowledged?	
(III) INCENTIVES What kinds of rewards (positive or negative) are given to students to encourage learning? • Teacher expounds on correct answers given by students • Teacher praises students verbally • What is the response when a wrong answer is given? • Are students encouraged to speak on when their ideas do not appear clear?	

• Are soft-spoken speakers encouraged to speak?	
(IV) ACHIEVEMENT OF SET OBJECTIVES Achievement of set objectives is apparent in: - • Activities • Teacher Questions • Students' Questions • Students' Answers • Level of Enthusiasm	
(V) EVALUATION OF LESSON BY TEACHER • Was evaluation incorporated in the plan? • Did the teacher actually evaluate the lesson? • Did the teacher indicate measures to be taken to improve future planning and execution?	

SOURCE: Adapted from Magoma (1999)

PART B

OBSERVATION OF TEACHING

NAME OF THE TEACHER	Satisfactory	Non-satisfactory
1. Planning e.g. Teaching plan clearly related to the intended learning outcomes		
2. Knowledge of subject matter e.g. content is up to date		
3. Embedding research e.g. makes use of current research, where appropriate		
4. Level e.g. content is at appropriate level for students		
5. Teaching methods e.g. methods are appropriate for the intended learning outcomes		
6. Structure e.g. the structure of the session is clearly set out to students		
7. Student involvement e.g. the students are actively engaged with the material		
8. Presentation e.g. there is appropriate use of audio visual and other technology aids. The lecturer/ teaching fellow can be heard at the back room and pronunciation is clear.		

Appendix V: Lesson plan

LESSON PLAN INCORPORATING PBLS IN PHYSICS BY TEACHER X

TOPIC: FLUID FLOW **DURATION:** 80 MINUTES

SUB-TOPIC: EQUATION OF CONTINUITY **CLASS:** FORM TWO

OBJECTIVE:

By the end of the lesson, the learner should be able to derive the equation of continuity.

Pre-requisite skills and knowledge

-streamline flow of a fluid

-turbulent flow

Teaching and Learning Resources

Smartphones and Laptops=- visit https//www.google.com/url

Physics KLB 4th Edition Form 2

References

Certificate Physics Form 2 by Waititu M. et al

Comprehensive Secondary Physics Form 2 by Muriithi W. and Rengeira D.

Physics Book 2 by Ashwork A.E

LESSON STAGES

STAGE/TIME	TEACHING/LEARNING ACTIVITIES	LEARNING POINTS	REMARKS
INTRODUCCTION (5MINUTES)	Learners are asked Questions e.g • what is streamline flow • what is turbulent flow	• Smooth/steady flow • Disturbed flow • Flow with Eddies	
LESSPON DEVELOPMENT (70	➢ Learners go into their groups ➢ Worksheets are provided by the teacher ➢ In their groups the learners choose their chair and	• Relationship between area and speed of a fluid flowing through a pipe of varying cross-sectional area.	

MINUTES)	secretary. They then carry out activities on the work sheets- (Discussion on how to derive the equation of continuity using KLB Book 2.) ➢ Learners collaboratively come up with their findings. ➢ Learners make presentation of their findings ➢ Teacher harmonizes ideas ACTIVITY TWO ✓ Learners watch a video clip on laptop/computer/smartphone ✓ Learners describe and illustrate the derivation of equation of continuity ✓ Teacher harmonizes observations and responses	• Flow Rate • Equation of Continuity • A_1V_1=A_2V2	
CONCLUSION (5 MINUTES)	Teacher leads learners to summarize main concepts	In derivation of equation of continuity, Assumptions made are as follows: 1. Fluid flows steadily 2. Fluid is incompressible 3. Fluid is non-viscous Flow rate is CONSTANT which yields equation of continuity relating area and speed of the fluid flowing in the pipe. A_1v_1_=A_2V_2	

LESSON EVALUATION

A good lesson, the lesson objective was achieved and learners were able to do exercises that involved the equation of continuity.

LESSON PLAN INCORPORATING PBLS IN PHYSICS BY TEACHER Y

TOPIC: FLUID FLOW **DURATION:** 80 MINUTES

SUB-TOPIC: EQUATION OF CONTINUITY **CLASS:** FORM TWO

OBJECTIVE:

By the end of the lesson, the learner should be able to derive the equation of continuity.

Pre-requisite skills and knowledge

-streamline flow of a fluid

-turbulent flow

Teaching and Learning Resources

. Smartphones and Laptops=- visit https//www.google.com/url

Physics KLB 4^{th} Edition Form 2

References

Certificate Physics Form 2 by Waititu M. et al

Comprehensive Secondary Physics Form 2 by Muriithi W. and Rengeira D.

Physics Book 2 by Ashwork A.E

LESSON STAGES

STAGE/TIME	TEACHING/LEARNING ACTIVITIES	LEARNING POINTS	REMARKS
INTRODUCCTION (5MINUTES)	Learners are asked Questions e.g • what is streamline flow • what is turbulent flow	• Smooth/steady flow • Disturbed flow • Flow with Eddies	
LESSPON DEVELOPMENT (70 MINUTES)	➢ Learners go into their groups ➢ Worksheets are provided by the teacher ➢ In their groups the learners choose their chair and secretary. They then carry out activities on the work sheets-(Discussion	• Relationship between area and speed of a fluid flowing through a pipe of varying cross-sectional area. • Flow Rate • Equation of Continuity	

	on how to derive the equation of continuity using KLB Book 2.) ➢ Learners collaboratively come up with their findings. ➢ Learners make presentation of their findings ➢ Teacher harmonizes ideas ACTIVITY TWO ✓ Learners watch a video clip on laptop/computer/smartphone ✓ Learners describe and illustrate the derivation of equation of continuity ✓ Teacher harmonizes observations and responses	• $A_1V_1=A_2V2$	
CONCLUSION (5 MINUTES)	Teacher leads learners to summarize main concepts	In derivation of equation of continuity, Assumptions made are as follows: 4. Fluid flows steadily 5. Fluid is incompressible 6. Fluid is non-viscous Flow rate is CONSTANT which yields equation of continuity relating area and	

			speed of the fluid flowing in the pipe. A_1v_1_=A_2V_2	

LESSON EVALUATION

A good lesson, the lesson objective was achieved and learners were able to do exercises that involved the equation of continuity.

LESSON PLAN INCORPORATING PBLS IN PHYSICS BY TEACHER Z

TOPIC: FLUID FLOW **DURATION:** 80 MINUTES

SUB-TOPIC: EQUATION OF CONTINUITY **CLASS:** FORM TWO

OBJECTIVE:

By the end of the lesson, the learner should be able to derive the equation of continuity.

Pre-requisite skills and knowledge

-streamline flow of a fluid

-turbulent flow

Teaching and Learning Resources

. Smartphones and Laptops=- visit https//www.google.com/url

Physics KLB 4th Edition Form 2

References

Certificate Physics Form 2 by Waititu M. et al

Comprehensive Secondary Physics Form 2 by Muriithi W. and Rengeira D.

Physics Book 2 by Ashwork A.E

LESSON STAGES

STAGE/TIME	TEACHING/LEARNING ACTIVITIES	LEARNING POINTS	REMARKS
INTRODUCCTION (5MINUTES)	Learners are asked Questions e.g • what is streamline flow • what is turbulent flow	• Smooth/steady flow • Disturbed flow • Flow with Eddies	
LESSPON DEVELOPMENT (70 MINUTES)	➢ Learners go into their groups ➢ Worksheets are provided by the teacher ➢ In their groups the learners choose their chair and secretary. They then carry out activities on the work sheets-(Discussion	• Relationship between area and speed of a fluid flowing through a pipe of varying cross-sectional area. • Flow Rate • Equation of Continuity	

	on how to derive the equation of continuity using KLB Book 2.) ➢ Learners collaboratively come up with their findings. ➢ Learners make presentation of their findings ➢ Teacher harmonizes ideas ACTIVITY TWO ✓ Learners watch a video clip on laptop/computer/smartphone ✓ Learners describe and illustrate the derivation of equation of continuity ✓ Teacher harmonizes observations and responses	• $A_1V_1=A_2V2$	
CONCLUSION (5 MINUTES)	Teacher leads learners to summarize main concepts	In derivation of equation of continuity, Assumptions made are as follows: 7. Fluid flows steadily 8. Fluid is incompressible 9. Fluid is non-viscous Flow rate is CONSTANT which yields equation of continuity relating area and	

			speed of the fluid flowing in the pipe. $A_1v_1 = A_2V_2$	

LESSON EVALUATION

A good lesson, the lesson objective was achieved and learners were able to do exercises that involved the equation of continuity.

LESSON PLAN INCORPORATING PBLS IN PHYSICS BY TEACHER P

TOPIC: FLUID FLOW **DURATION:** 80 MINUTES

SUB-TOPIC: EQUATION OF CONTINUITY **CLASS:** FORM TWO

OBJECTIVE:

By the end of the lesson, the learner should be able to derive the equation of continuity.

Pre-requisite skills and knowledge

-streamline flow of a fluid

-turbulent flow

Teaching and Learning Resources

. Smartphones and Laptops=- visit https//www.google.com/url

Physics KLB 4th Edition Form 2

References

Certificate Physics Form 2 by Waititu M. et al

Comprehensive Secondary Physics Form 2 by Muriithi W. and Rengeira D.

Physics Book 2 by Ashwork A.E

LESSON STAGES

STAGE/TIME	TEACHING/LEARNING ACTIVITIES	LEARNING POINTS	REMARKS
INTRODUCCTION (5MINUTES)	Learners are asked Questions e.g • what is streamline flow • what is turbulent flow	• Smooth/steady flow • Disturbed flow • Flow with Eddies	
LESSPON DEVELOPMENT (70 MINUTES)	➢ Learners go into their groups ➢ Worksheets are provided by the teacher ➢ In their groups the learners choose their chair and secretary. They then carry out activities on the work sheets-(Discussion	• Relationship between area and speed of a fluid flowing through a pipe of varying cross-sectional area. • Flow Rate • Equation of Continuity	

	on how to derive the equation of continuity using KLB Book 2.) ➢ Learners collaboratively come up with their findings. ➢ Learners make presentation of their findings ➢ Teacher harmonizes ideas ACTIVITY TWO ✓ Learners watch a video clip on laptop/computer/smartphone ✓ Learners describe and illustrate the derivation of equation of continuity ✓ Teacher harmonizes observations and responses	• $A_1V_1=A_2V2$	
CONCLUSION (5 MINUTES)	Teacher leads learners to summarize main concepts	In derivation of equation of continuity, Assumptions made are as follows: 10. Fluid flows steadily 11. Fluid is incompressible 12. Fluid is non-viscous Flow rate is CONSTANT which yields equation of continuity relating area and	

		speed of the fluid flowing in the pipe. A_1v_1_=A_2V_2	

LESSON EVALUATION

A good lesson, the lesson objective was achieved and learners were able to do exercises that involved the equation of continuity.

Appendix VI: Public sub-county girls' schools in Bungoma County

NO.	SCHOOL	DAY/BOARDING
1	Bungoma Baptist	GD
2	Matumbufu Girls	GB
3	Siangwe Girls	GB
4	Kaptelelelio Girls	GD
5	St, Kizito- Mukhweya	GD
6	Girls	GD
7	Sanandiki Girls	GD
8	Bakisa Girls	GB/D
9	Karibuni Girls	GB/D
10	Binyenya Girls	GD
11	Geoff-Brown Girls	GD
12	Sibumba Girls	GD
13	Kolani Girls	GD
14	Tulienge Girls	GD
15	St. Augustine Sitabicha	GD
16	S.A Mufungu Girls	GD
17	Malakisi Muslim Girls	GD
18	St. Pauls Miluki Girls	GB
19	Nang'eni Girls	GB/D
20	S.A Nalondo Girls	GD
21	S.A Chebosi girls	GD
22	Milo Friends Girls	GD
23	Namunyiri Girls	GB
24	Kikai Girls	GD
25	Bumula Friends Girls	GB
26	Mwiruti Girls	GB/D
27	Kim Girls	GB/D
28	Mukuyuni Girls	GB/D
29	Mungore Girls	GB/D
30	Nzoia Sugar Girls	GB/D
31	Mbakalo Friends Girls	GB/D
32	St. Teresa Girls Cheptais	GB/D
33	Marobo Girls	GB/D
34	Mabanga Girls	GB/D
35	Bishop Atundo Mabusi	GB/D
36	S.A Kabuchai Girls	GB
	Kimilili Friends	

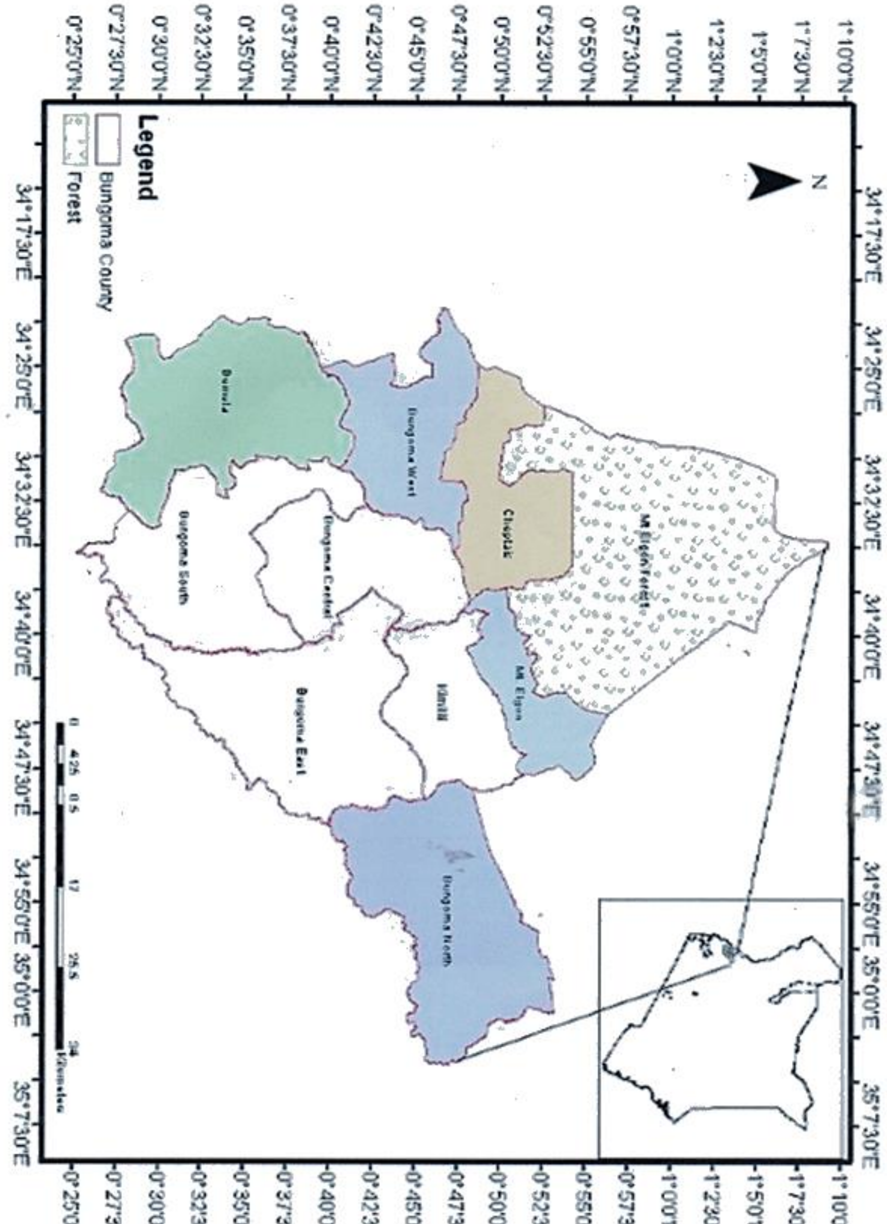
KEY

GB- GIRLS BOARDING

GD- GIRLS DAY

GB/D- GIRLS BOARDING/DAY

Appendix VII: Bungoma County Map



Appendix VIII: Introduction letter

University of Eldoret
flame of knowledge and innovation

P.O. Box 1125-30100, ELDORET, Kenya
Tel: 053-2063111/8 Ext.2032
Fax No. 20-2141257
Email: soe@uoeld.co.ke
www.uoeld.ac.ke

UNIVERSITY OF ELDORET

SCHOOL OF EDUCATION
CENTRE FOR TEACHER EDUCATION

Ref: UOE/B/CTE/REF/034 2nd August, 2022

To
The Executive Secretary,
National Council for Science and Technology,
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

SUBJECT: RESEARCH PERMIT FOR: MANG'ENI GLADYS NASAMBU
REG. NO.: SEDU/CTE/P/001/19

This is to confirm that the above named Post Graduate Student has completed Course Work and has successfully defended her thesis proposal.

She is currently preparing for a Field Research Work on her thesis entitled: *Effect of problem based learning strategy on achievement in physics: A case study of sub-county girls' secondary schools in Bungoma county-Kenya.*

Any assistance accorded to her to facilitate successful conduct of the research will be highly appreciated.

Yours Faithfully,

HEAD
Centre for Teacher Education
UNIVERSITY OF ELDORET
MAIN CAMPUS

DR. R. M. AMIN'GA
HEAD, CENTRE FOR TEACHER EDUCATION

Appendix IX: County director of Education

REPUBLIC OF KENYA

MINISTRY OF EDUCATION
State Department of Basic Education and Early childhood – Bungoma County

When Replying please quote
e-mail: bungomacde@gmail.com

Ref No: BCE/DE/19/VOL.II1/215

County Director of Education
P.O. Box 1620-50200
BUNGOMA

Date: 26th August 2022

TO WHOM IT MAY CONCERN

RE: AUTHORITY TO CARRY OUT RESEARCH.

NACOSTI/P/22/19661

The bearer of this letter ***Ms. Gladys Nasambu Mang'eni of Eldoret University*** has been authorized to carry out research on ***"Effects of Problem Based Learning Strategy on Achievement in Phyics: A Case Study of Sub County Girls Secondary Schools in Bungoma County - Kenya"*** for the period ending 17th August 2023.

Kindly accord her the necessary assistance.

For: COUNTY DIRECTOR OF EDUCATION
BUNGOMA
P.O. Box 1620,
50200

CALEB OMONDI
FOR COUNTY DIRECTOR OF EDUCATION
BUNGOMA COUNTY

ISO 9001 SGS

Appendix X: County Commissioner

REPUBLIC OF KENYA

THE PRESIDENCY
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telephone: 055-30326.
Fax: 055-30326.
E-mail: ccbungoma@yahoo.com
When replying please quote

Office of the County Commissioner
P.O. Box 550-50200
BUNGOMA.

REF:ADM.15/13/VOL.IV/06

26th August, 2022

ALL DEPUTY COUNTY COMMISSIONERS
BUNGOMA COUNTY.

RE: RESEARCH AUTHORIZATION

This is to inform you that Mrs. Gladys Nasambu Mang'eni of University of Eldoret has request for authority to conduct research in Bungoma County on the topic "Effect of problem based learning strategy on achievement in Physcis" for the period ending 17th August, 2023.

Authority is hereby granted for the specific period as per research license dated 17th August, 2022 License No. NACOSTI/P/22/19661 signed by Director General, National Commission for Science, Technology and innovation.

Any assistance accorded to her in this pursuit would be highly appreciated by this office.

Christine W. Chacha
For: County Commissioner
BUNGOMA COUNTY.

Appendix XI: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 957270

Date of Issue: 17/August/2022

RESEARCH LICENSE

This is to Certify that Ms.. GLADYS NASAMBU MANG'ENI of University of Eldoret, has been licensed to conduct research in Bungoma on the topic: EFFECT OF PROBLEM BASED LEARNING STRATEGY ON ACHIEVEMENT IN PHYSICS: A CASE STUDY OF SUB-COUNTY GIRLS\' SECONDARY SCHOOLS IN BUNGOMA COUNTY, KENYA for the period ending : 17/August/2023.

License No: NACOSTI/P/22/19661

957270

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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Appendix XIII: Publications

Can Learners Taught through Problem-Based Learning Strategy Demonstrate an Obligation to Conveying Positive Motivation towards Physics enrolment?

[1] **Mangeni Gladys Nasambu** *; [2]Peter Waswa and [3]Dinah Samikwo

[1;] PhD Student in the University of Eldoret; *Corresponding Author: gladysmangeni@gmail.com;
Tel +254712475399
[2] Lecturer in the Department Science Education at University of Eldoret
[3] Lecturer in the Department Science Education at University of Eldoret

Abstract

The government of Kenya has invested enormous resources such infrastructure development, learning materials and professional development of teachers. Despite the efforts put in place to support access and quality education, enrolment and performance in physics in most Sub-County girls' secondary schools in Bungoma County at Form 3 remain relatively low and poor. The study aimed at investigating whether learners taught through Problem Based Learning Strategy demonstrate an obligation to conveying positive motivation towards Physics achievement. The objective of the study was to establish the effect of problem-based learning strategy on girls' motivation towards "Fluid Flow" as compared to conventional teaching methods. The study adopted constructivist theories of learning. Quasi-Experimental design was used with 8 girls' schools targeted in Bungoma County. The study sampled Form two students because the topic of fluid flow is taught at form two. Simple random sampling was used to assign schools to experimental and control groups. The study used motivation questionnaire, physics Achievement Test (PAT) and Observation schedule. Two groups of each n=40 were either control or experimental were exposed to pretest and post-test. The reliability coefficient was calculated using KR-Fomulla-20 at 0.75. With the aid of SPSS 26.0, data was analysed using descriptive and inferential statistics and presented in form of tables. Results show statistically significant difference in motivation effect of Girls in the topic Fluid Flow using PBLS which was relatively higher than use of conventional methods (ANOVA ($F(4,155)$ = (Q2 = 459.886; Q16 = 462.375; Q24 = 831.272; Q26 =614.907 and Q28 = 406.743), $p = .000$). The study recommends the method should be strongly advocated by policy makers, the Government, Principals and teachers while teaching science subjects for effective skill development among the learners. The study is significant in bringing total reforms to CBC that call for the use of learner-centered instructional strategies to develop key competencies.

Key Words: Constructivists theory, Learner's Motivation, Problem-based learning strategy, Learner's Enrolment

1.0. Introduction

In today's 21st century, teaching and learning objectives are successfully achieved by enabling wholistic learner activities in schools. This is because learner characteristics are diverse and addressing such phenomenon in learning situation is critical. One aspect that drive learning process is by teachers facilitating good learning environment and motivation to individual learners (Borah, 2021).

Teaching within the Lens: The Use of Problem-Based Learning Strategy for Learner's Attainment of Critical Thinking Skills in Public Secondary Schools in Kenya

[1] **Mang'eni** Gladys Nasambu*; [2]Peter Waswa and [3]Dinah Samikwo

[1;] PhD Student in the University of Eldoret; *Corresponding Author: gladysmangeni@gmail.com; *Tel +254712475399*

[2] Lecturer in the Department of Science Education at University of Eldoret

[3] Lecturer in the Department of Science Education at University of Eldoret

ABSTRACT

The Problem-Based Learning Strategy (PBLS) is one of the most powerful instructional strategies on learning and achievement, but its impact can be determined arising from the behaviors of the learners who graduate after exposure to it. Its influence has been frequently mentioned in earlier researches but surprisingly most educators have systematically and consistently not adapted to it, resulting to lower Learning outcomes from the learners. This study provides the use of PBLS for learner's attainment of critical thinking skills in public secondary schools in Kenya. The objectives of the study were to determine the extent to which instructors' use PBLS as a teaching strategy to promote problem solving abilities of girls in Physics and evaluate the gain in problem solving abilities of girls in "Fluid Flow" when using problem-based learning strategy. The study adopted constructivist theories of learning. Quasi-Experimental design was used with 4 girls' schools targeted in Bungoma County. The study sampled Form two students because the topic of fluid flow is taught at form two. Simple random sampling was used to assign schools to experimental and control groups. The study used motivation questionnaire, physics Achievement Test (PAT) and Observation schedule. Two groups of each n=40 either control or experimental were exposed to pretest and post-test. The reliability coefficient was calculated using KR-Fomulla-20 at 0.75. With the aid of SPSS 26.0, data was analysed using descriptive and inferential statistics and presented in form of tables. Although there was inadequate use of PBLS before the experiment, results show that all the variables were significant, X^2 (4, N = 160) = 146.250, p = .000; X^2 (4, N = 160) = 194.688, p = .000; X^2 (4, N = 160) = 334.438, p = .000; X^2 (4, N = 160) = 200.750, p = .000. Thus, the use of PBLS as a teaching strategy promotes learner's CTS at the study area. Similarly, the study found significant difference in the level of girls problem solving abilities towards Fluid Flow, a topic in physics between students who were exposed to PBLS and those taught using conventional methods. There is need for upskilling or retraining of teachers for the adoption and use of PBLS in schools. We recommend the method should be strongly advocated by policy makers, the Government, Principals and teachers while teaching science subjects. The study is important in bringing public sector reforms in the education sector especially with the tune of Competency Based Curriculum.

Key Words: Constructivists theory, Learner's Attainment, Problem-based learning strategy, Learner's Critical Thinking Skills

Appendix XIII: Similarity Report

University of Eldoret

Certificate of Plagiarism Check for Synopsis

Author Name	MANGENI GLADYS NASAMBU SEDU/CTE/P/001/19
Course of Study	Type here...
Name of Guide	Type here...
Department	Type here...
Acceptable Maximum Limit	Type here...
Submitted By	titustoo@uoeld.ac.ke
Paper Title	EFFECT OF PROBLEM BASED LEARNING STRATEGY ON ACHIEVEMENT IN PHYSICS IN SUB-COUNTY GIRLS' SECONDARY SCHOOLS IN BUNGOMA COUNTY-KENYA
Similarity	12%
Paper ID	986459
Submission Date	2023-09-27 15:56:35

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